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DEMONSTRATION OF THE EVOLUTION AND THEORY OF THE VACUUM TUBE BY HYDRAULIC ANALOGY

BY F. JOSEPH LORZ
Monticello Junior High School,
Cleveland Heights, Ohio

Without the contribution made by the vacuum tube in detection, amplification and rectification—in transmission and reception—present day radio would have been impossible. The tube has been truthfully called "the heart of the set." It follows that a thorough understanding of it is prerequisite to that of the whole of radio theory and practice.

The system illustrated is designed to show the development of the present three-element tube from the two and the one-element tubes, successively. It is possible to begin with an analogy of the Edison Effect (one element), in which electrons are emitted from a heated filament in all directions. One may proceed from this to the Fleming valve (two elements), in which electrons no longer flow in all directions, but assume one-direction flow, from the filament where they are in excess, to the plate where they are deficient, and to end with the De Forest tube by the insertion of the grid as the control element between filament and plate.

This sequence in presentation parallels the historical development and appears to be pedagogically desirable.

In all three assemblies the streaming of electrons, which according to the theory constitutes current flow, is simulated by the flow of a colored liquid. The electronic control function of the grid, always difficult to present in the abstract, may be

particularly emphasized. The implied concept is that electrons flow from a position of excess to one of deficiency, which terminology is preferred by the writer to the often confusing reference to positive or negative electricity. This control, according to the theory and to the analogy, is determined by the concentration of electrons on the grid which accordingly as they are excessive or deficient, alternately assists and opposes flow from filament to plate.

The apparatus analogous to the Edison Effect consists of a piece of small bore, hairpin shaped, copper tubing perforated in all directions near the bend and closed at one end. The other end is connected to a flask from which the liquid is forced with a pressure bulb. The tubing representing the filament is inserted in a glass globe at the bottom of which and carrying the tubing is a funnel to gather the liquid discharged from the filament.

The Fleming valve can be demonstrated by inserting, in the same glass globe, filament tubing having holes on one side to emit the fluid in that direction only. A plate, placed about two inches from this, is a piece of flat metal with an integral thin receiving arrangement at the bottom. This is connected with a glass tube which returns to the flask. Within the flask, at the end of the plate tube, is a rubber-stopper Bunsen valve, which opens to permit liquid to flow down into the flask, but which is closed by air pressure when the pressure bulb is subsequently squeezed.

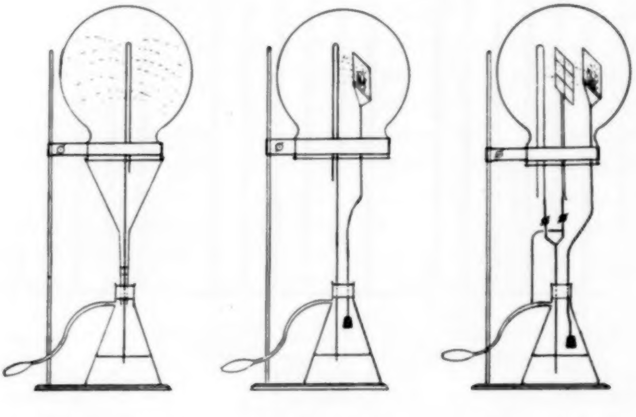
Pressure on the rubber bulb causes six jets of liquid from the filament to arc across the gap between filament and plate where they are received on the plate and returned to the flask. The analogy here is that excess electrons on the filament flow to the position of deficiency, the plate. In an actual hook-up the plate is always deficient by reason of its electrical connection to B-battery or transformer.

The insertion of a grid between filament and plate as above, constitutes the analogy of the De Forest vacuum tube. The grid consists of a small bore glass tube bent continuously to form six squares, in which the tubing overlaps, of necessity. This is also connected to the flask. Pressure on the rubber bulb causes the liquid to rise and circulate through the grid. The simulation of a stream of electrons is enhanced by atomizing this column of liquid by means of a side jet of air introduced into the grid tube from the pressure bulb.

In use, the grid is first flooded. Because both grid and filament receive liquid from the same flask, it is necessary to close the glass valve of one or the other; of the former when the filament is to be flooded, of the latter when the grid is to be flooded.

This flooding of the grid represents an excess of electrons there. Hence the grid opposes the flow from filament to plate. Emptying the grid may be effected by forcing the small quantity of liquid necessary to fill it on through its open end.

Thus empty, it represents a condition of deficiency there. Accordingly, the grid assists the already deficient plate to attract electrons from the filament. This is represented in the system by the flow of the jets of liquid through the grid to the plate, thence back to the flask effected by again squeezing and releasing the pressure bulb.



EDISON EFFECT FLEMING VALVE DEFOREST TUBE

It is this shuttle-like control function of the grid, shown by the alternate flooding and draining and the consequent hindering and helping of flow from filament to plate, which offers greatest difficulty in presentation. Pictorial analogies in texts in which apples or marbles represent electrons appear to be less convincing than the actual flow of a liquid.

Broadly speaking, the flask as the source of current might be compared to the A and B batteries in a hookup set. Mechanical difficulty would prevent extension of the analogy to include a complete one-tube hook-up. The analogy described is not intended to extend beyond the radio tube itself.

TRENDS IN HIGH SCHOOL MATHEMATICS

By Alvin W. Johnson
Union College, Lincoln, Nebraska

The past 35 years (1899–1935) have, in Nebraska as in other states, marked not only an increase in school population, but also a great increase in the enrollment of the secondary schools. This increase in high school enrollment has brought about increments in the offerings, and a shifting of emphasis in certain subjects and in certain fields of study. Figures 1 and 2 show the attitude of the secondary schools of Nebraska toward mathematics, the shifting of emphasis in connection with certain subjects and the place of mathematics in the program of studies.

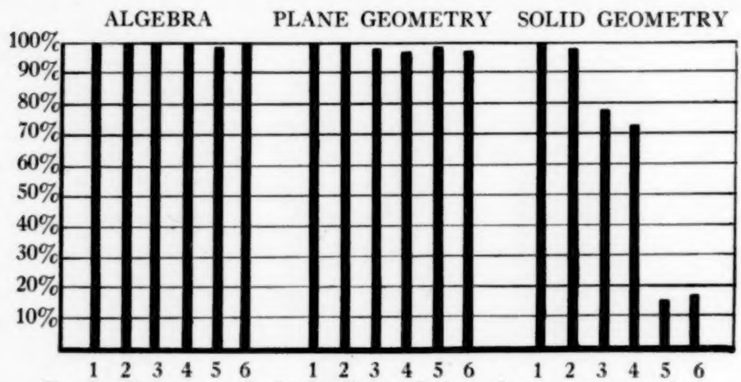


Fig. I.—Percentage of schools offering algebra, plane geometry, and solid geometry for the years tabulated.

1—1899–1900 3—1913–14 5—1927–28
2—1906–07 4—1920–21 6—1934–35

The results as revealed by the charts are based on a study made of all the original programs of studies for the secondary schools of Nebraska, both public and private, for the school years 1899–1900, 1906–07, 1913–14, 1920–21, 1927–28 and 1934–35.[1]

In the field of mathematics algebra has always held an important place in the offerings of the Nebraska schools. For the years studied every school with the exception of one offered this subject.[2] The amount of time devoted to offerings in algebra varied from one to three years. The average amount of time devoted to offerings in algebra for the school year 1899–1900 was

[1] A few schools were omitted because of lack of reliable information.

[2] One exception appeared in the school year 1927–28. This is possibly an error resulting from the failure on the part of the one filling out the report to list algebra.

1.7 years. This was reduced in the year 1906–07 to 1.5 years; in 1913–14 the offerings were further reduced to 1.06 years. By 1920–21 the programs of studies revealed an increase in the offerings in algebra with an average of 1.5 years per school. A slight increase was shown in 1927–28, the average being 1.6 years, which was the amount of time allotted to the subject in 1934–35.

Every secondary school in Nebraska offered plane geometry in 1899–1900. This was still true in 1906, since then a few exceptions have appeared. Last year out of 485 schools tabulated seven failed to offer plane geometry. With the beginning of the century many schools offered only a half year, some $\frac{1}{3}$ or $\frac{1}{4}$ of a year. The average for all schools in 1899–1900 was .86 of a year.

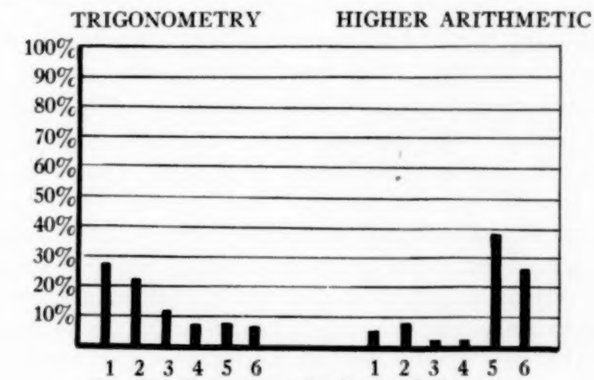


FIG. II.—Percentage of schools offering trigonometry and higher arithmetic.

1—1899–1900 3—1913–14 5—1927–28
2—1906–07 4—1920–21 6—1934–35

The great majority of schools are at present offering 1 year of plane geometry.

Figure 1 shows the great change that has taken place in the offerings in solid geometry. In 1899 every school offered some work in solid geometry. These offerings ranged from $\frac{1}{6}$ to $\frac{3}{4}$ of a year. The common practice was to offer a half year course. By 1935 less than 16 per cent of the schools offered solid geometry. Of these 90 per cent offer it as a half year subject.

As revealed by Figure 2 trigonometry never held an important place on the Nebraska program. Its significance has tended to decline until only 7 per cent of the schools offer the subject in 1935 whereas 28 per cent of the Nebraska schools offered trigonometry at the beginning of the century. As is the case with solid geometry the practice is also to offer trigonometry as a

half year subject by those schools which include it on their program.

Higher arithmetic has experienced just the opposite effects from that of trigonometry and solid geometry. While higher arithmetic has always appeared in the offerings of a few schools its appearance has increased considerably until by 1927 it appeared among the offerings of 38 per cent of the schools. Though 1935 showed a decrease it is still offered by about 27 per cent of the schools. There is no doubt that the increased interest manifested in recent years in the commercial arts served to attract some interest to the subject of higher arithmetic; however, the latter should not be confused with commercial arithmetic which also experienced considerable growth.

Considering the field of mathematics as a whole the programs of study reveal that there has been a general decrease in the amount of time devoted to offerings in this field in the Nebraska schools. The average amount of time devoted to all offerings in mathematics in the school year 1899–1900 was 3.3 years per school. In 1906–07 the average was 3 years; in 1913–14, 2.9 years; and in 1920–21, 2.8 years. By 1927–28 the average offering per school increased to 3 years but by 1934–35 the average amount of time devoted to offerings in mathematics was again reduced to 2.8 years, the same as in 1920–21. As we have seen, within the field itself, algebra and plane geometry have remained almost constant, though there has been a growing tendency for a few schools to omit geometry entirely from their offerings. Solid geometry has experienced a heavy decrease with only 15 per cent of the schools of Nebraska offering the subject at the present time. Likewise trigonometry has shown a decrease while higher arithmetic has shown an increase.

SAMPLES OF MAYAN POTTERY DISCOVERED

Entering a tomb in the Guatemalan Highlands, Dr. A. V. Kidder of the Carnegie Institution of Washington has discovered the most remarkable pottery vessels of America's ancient Mayan civilization yet revealed.

Cabled report of the discovery to the Carnegie Institution, states that some of the fine pieces of this ancient art are coated with stucco and adorned with paintings of the Mayan gods. A magnificent effigy was also removed from the tomb.

Other tombs have been identified at this site, where the expedition recently discovered three pyramids built one over the next like a nest of blocks. Objects being taken from the tombs as they are opened are to be removed to the archaeological museum in Guatemala City.

MENDEL'S LAWS

By Thomas Curtin[1] and O. E. Underhill
Teachers College of Connecticut, New Britain, Connecticut

This project originated in a discussion of the Mendelian laws with a ninth grade general science class. It was thought that the pupils would be more interested if something concrete and involving more activity were developed than the textbook diagrams provided. Thus a board was constructed on which the laws could be pictured and diagrammed as they were discussed.

This board was made from a rectangular piece of wood, approximately fifteen by twenty inches. Four rows of one inch brads were driven into the board to form pegs on which cardboard cut-outs could be hung. The top row, representing the parent generation, had two nails, and each of the remaining rows, four nails. These rows were labeled respectively "Parents," "First Generation," "Second Generation" and "Third Generation." The accompanying illustration shows the use of this board.

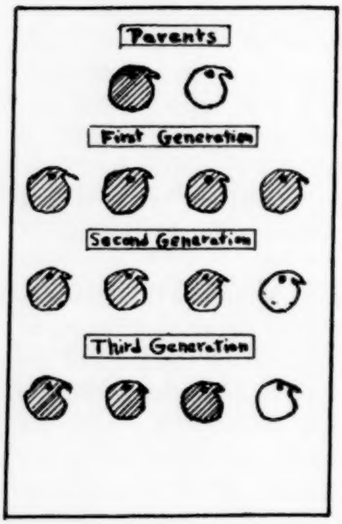
The text being used[2] had diagrammed Mendel's law describing the 1–2–1 ratio, wherein the hybrid generation phenotype is different from that of either parent, in four-o'clocks, and the 1–3 ratio, wherein the hybrid phenotype is the same as that of the dominant parent, in peas. A number of cut-outs resembling four-o'clocks were made from stiff cardboard, some red, some pink and some white, and a hole punched in each cut-out so that it could be hung on the proper nail. In a similar manner cut-outs of pea seeds were made from yellow and from green cardboard. More cut-outs should be made than needed to fill the nails properly. Otherwise, when a student is asked to select the proper cards to fill out the diagram he may be guided by the fact that as he nears the end of his task only the proper cards will remain.

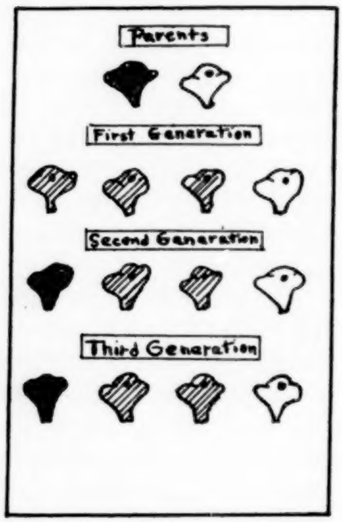
After class discussion to make meaningful the terms "dominant traits," "recessive traits," "ratios," "hybrid," "pure," "self-pollination" and "cross-pollination" the board is brought into use. A pupil is asked to select from the four-o'clock cards

[1] Mr. Curtin, a junior in the Junior High School Department, worked this lesson out in connection with his practice teaching at the Central Junior High School under the supervision of Mr. R. E. Tripp, critic teacher, and O. E. Underhill, Instructor in Science at Teachers College of Connecticut.

[2] Powers, Neuner and Bruner. A Survey of Science, Book III, Man's Control of His Environment. Ginn and Co. 1935, pp. 43–51.

two that would represent a pure dominant and a pure recessive, and to place them on the board as parents. The class is then asked to explain what is done to these parents (cross-pollination) and a pupil is asked to set up the resulting first generation. (All pink.) In a similar manner the second generation, showing the 1–2–1 ratio is set up. Here care must be taken to have the class understand that this is a ratio representing many offspring. The next row is then set up, making clear of course, that hybrids are being crossed, and again the 1–2–1 ratio appears. This could be made more clear if desired by setting up the fourth





row with twenty nails, and showing the results of each of the five possible crosses (pure red with pure red, pure white with pure white, pure red with hybrid, pure white with hybrid, hybrid with hybrid) or each of these five combinations may be taken as parents and the F_1 worked from them. This is perhaps carrying the matter further than is desirable in a general science class, but this method could easily be elaborated for use in biology classes where the study of genetics would be carried further.

With the use of peas we have the problem of making clear the difference between phenotype and genotype. (Of course these terms need not be used.) The first generation will be developed in the same manner as the four-o'clocks, except that

instead of having a hybrid intermediate between the two parents, we have one showing the dominant trait, in this case yellow. The F_2 generation then shows the ratio of three yellow to one green. Here then is a problem. On the next cross, if we take any two of the three yellow seeds will we get the same results, as we did when we took any two of the pink four-o'clocks? The instructor should then develop through discussion the idea that although the three seeds look alike, they may differ genetically and must be bred to determine in what way they differ. By referring to the experience with the four-o'clocks it can be argued that there should be one pure and two hybrid, so that one-third of the yellow seeds of the F_2 should be pure, and two-thirds hybrids. The yellow cut-outs may now be marked on one side to identify them as pure or hybrid. The fact that one cannot tell the genetic character of a hybrid of this type by looking at it may be emphasized by setting up two of the yellow cut-outs (marked side hidden) as parents, and asking what the next generation will be. Or the instructor may set up an F_1 generation (all yellow, or three yellow and one green) and ask what the parents were. Of course in the all yellow case there are three possibilities (pure yellow with pure yellow, pure yellow with hybrid yellow, or pure yellow with green). However, if the matter of backcrossing hybrid with pure parent has not been taken up the instructor will take care that the cards he has selected for the parents are either two pure yellow, or two hybrid yellow. In case of biology classes which have carried the study sufficiently far, the class should consider all possibilities, and be asked to show how the true state of affairs may be traced down by further breeding.

After the discussion the board may be used as review by having one student carry through the complete discussion, using the board for illustration as he talks. In using this board it was found that the students were much more alert and interested during its use than when the discussion dealt with textbook material only. The cost of this apparatus was five cents—the price of the colored cardboard. In test questions covering the work on this unit those items dealing with the materials relating to the discussion carried on with the board were better answered than other questions on the test. Other factors may have been responsible for this of course, but it seems likely that the project was in large part responsible for the better showing.

SELECTED TOPICS IN ACOUSTICS

By F. R. Watson
University of Illinois, Urbana, Illinois

"If you hold a sea shell to your ear, you will hear the sounds that it collected when it lay on the seashore listening to the waves." This romantic and rather sad thought is not supported by science. If I cup my two hands to imitate a sea shell and hold them to my ear, I get the same effect as with the shell. Now, I am sure my hands have not been collecting sounds on the seashore, although I should thoroughly enjoy allowing them, and the rest of me, to pick up some sunburn on the Florida beaches. The explanation lies in the fact that the shell and the hands both act as resonators, the enclosed volume of air reenforcing certain sounds that come to them. In a perfectly quiet room, there would be no response, because the resonator reenforces only the sounds that are actually present.

"But," you say, "science takes all the poetry out of nature!" While it is true that science dispels some popular misconceptions, it nevertheless gives back to the public far more enjoyment than it takes away. For example, suppose someone twenty years ago had made the statement: "I plan to talk to the whole world at one time," we would have questioned his sanity; but now the President of the United States, without leaving his desk in the White House, can talk over the radio so as to be heard in all parts of the country and abroad. We may not agree with what he says, but we cannot fail to be impressed with the miracle of broadcasting, which surpasses the most fantastic fairy tales.

The science of sound, always fascinating for people, has been making rapid progress in modern times. It has been necessary to redefine acoustic terms. Instead of the time-honored custom of designating the characteristics of a musical sound as the pitch, intensity, and timbre, they are now called frequency, or the number of cycles per second, the intensity, or the energy per square centimeter per second, and the tone-structure, which depends on the number of pure tones that are present in a sound. Furthermore, there is a long list of new definitions and names that cover the phenomena of acoustics.

The acoustic achievements in modern times are quite numerous. The development of the thermionic vacuum tube has led to astonishing results in the broadcasting of speech and music,

in the production of sound motion pictures, and in the easy and efficient generation and measurement of sound. The physiology and psychology of hearing have been studied extensively, largely by the research staff of the Bell Telephone Laboratories, so that the performance of the ear is much better understood. In these investigations, a new system of hearing units, called decibels, has been developed and is coming into common use in the measurement of noise and its reduction. Cooperative projects carried out jointly by scientists and musicians have given results beneficial to both groups, as shown by the reproduction in Washington of an orchestral concert given in Philadelphia, an experiment which utilized three separate telephone transmission lines, each line with special equipment, in the attempt to secure "auditory perspective." Another similar cooperation is found in the publication of a book, "The Voice," under the joint authorship of a musician and a scientist. The acoustic adjustment of auditoriums and the quieting of offices and buildings, so ably begun by Wallace Sabine, have progressed rapidly in recent years. More recently, a new science of supersonics has appeared that deals with the rather surprising properties of sound waves with high frequencies beyond the range of hearing. One unexpected extension of the study of music has been the development of high-school orchestras and bands, largely because of the initiative of Joseph P. Maddy. In 1929 the Acoustical Society of America was organized and now numbers about 700 enthusiastic members.

In selecting material for the present discussion, I have considered the topics that would have both scientific and mathematical interest, in accordance with the objects of this Association. I have therefore chosen the tuning fork and its associated phenomena as appropriate subjects for discussion.

The tuning fork is one of the most common and most useful of acoustic instruments. It maintains a constant frequency indefinitely, which varies only slightly with temperature and amplitude of vibration. It is a dynamically balanced system in which the prongs move simultaneously outward and, one-half period later, simultaneously inward. The fork may be considered as made up of two equal rectangular bars fixed at the bottom and free to move at the upper end. Or it may be thought of as a modification of a vibrating bar, free at both ends. Starting with the straight bar, the nodal points, about one-fourth the length of the bar from each end, move toward the center as

the bar is bent, until in the tuning-fork arrangement with the two sections of the bar parallel, the nodes are very close together. When the tuning-fork prongs vibrate, it is seen that there is a tendency for a small up-and-down motion between the nodes at the base of the fork. Thus, if the stem of the fork is touched to a table top or other resonating device, a vibration is set up in unison with the fork, which makes the radiated sound louder but which uses up the energy faster and damps out the fork's motion more quickly.

If we examine the motion of the fork more in detail, we find that each vibrating prong acts as a "double source" of sound; that is, taking the illustration given by Stokes, suppose a person moves his hand slowly to and fro through a small space in air. The air immediately in front of the hand is pushed forward, while the air behind is impelled after the moving hand. There is thus a slight compression in front of the hand and a small rarefaction behind it with the result that the air tends to flow backwards from the compression to the rarefaction. If the to and fro motion is made more rapid, there is less time for the equalizing flow and the compressions and rarefactions begin to set up sound waves.

If a vibrating sphere is substituted for the hand, the lines of flow are the same as the lines of force of a small magnet with a maximum flow existing perpendicularly to the imaginary plane passing through the equator of the sphere. In this plane, the compressions and rarefactions just offset each other, so that no sound can be detected here. If the imaginary plane were made solid, the flow would be stopped and the resultant sound would be louder.

Returning to the tuning fork, each prong acts as a double source, with the two sources exactly opposite in phase. When the two prongs of the tuning fork approach each other, they "squeeze out" a compression between them but also set up a rarefaction behind each prong. A half period earlier, exactly the opposite effect existed—a reduced pressure (rarefaction) was formed between the receding prongs with a compression in front of each advancing prong. These compressions and rarefactions travel outward and overlap along four lines, producing silence, which may be observed by turning the fork near the ear so that the lines of silence pass by. They may also be demonstrated in a lecture room by rotating the fork over the top of a resonating glass jar, which will give magnified sounds except when the lines

of silence pass down the tube, when the sound ceases. Placing a cylinder of paper over one prong without touching it will stop the phenomenon. Furthermore, if a flat object is placed in a line of silence, the lateral flow between compressions and rarefactions that reduces the sound intensity will be stopped, and the resultant sound will be louder. If flat objects were placed in all four lines of silence, there would be a still larger increase in the loudness.

This rather surprising reenforcement is exemplified further in the case of a vibrating wire, which may also be regarded as a double source. The flow of air around a wire with a low frequency is so great that the sound is practically inaudible, which shows why a sounding board is of vital importance in amplifying the sounds of piano strings. If the lateral flow about the wire were prevented by a series of planes passing through the axis of the wire, the resultant sound, according to Professor Stokes, would be 40,000 times more intense, an increase of 47 decibels.

But I have just introduced the term "decibel," which is the modern unit for expressing the loudness of sounds as perceived by the ear. Investigations show that the hearing sensation is proportional to the logarithm of the sound intensity. It thus follows that the difference in decibel level between two sounds is defined to be given by ten times the logarithm of the ratio of the intensities of the two sounds. For example, assuming that 100 violins give out a resultant sound that is 100 times more intense than one violin, the difference in decibels between the sounds is $10 \log_{10} 100/1$, or 20 decibels. The scale of sounds in decibels that the ear perceives ranges from "threshold" sounds with zero decibels to loud sounds, ten billion times more intense than the threshold sounds, with 100 decibels loudness. For purpose of comparison with other sensations, it may be said that 100 decibels of sound are about as uncomfortable to the ear as a temperature of 100 degrees is to the body. Furthermore, a reduction of the sound to 70 decibels will bring about the same relief as a drop in temperature to 70 degrees.

An amusing illustration of the use of decibels is given by the riddle, "what makes more noise than a pig under a gate?" the answer is *two* pigs. But if the two pigs are equal in their squeals, the decibel loudness difference is 10 log 2, or 3 decibels. Since in practical work, it requires about 5 decibels difference between two sounds to distinguish them, an observer could not tell by his ear any difference if one pig stopped squealing.

This reduction in 3 decibels may be tested by the following experiment. Select two tuning forks as nearly alike as possible, preferably mounted on resonance boxes to amplify the sound. Adjust them to give about one beat in 2 seconds, then strike the forks with equal blows, making a number of trials until the minimum loudness in the beat tone is as near silence as possible. When this condition is reached, stop one of the forks when the beat tone reaches its maximum loudness, and then estimate by the ear whether there is any apparent reduction in loudness. The difference in decibels in stopping one of the forks is 3 db, because the resultant intensity is 2 E, where E is the intensity of either fork sound. The difference in decibels is thus: $L=10 \log 2\,E/E= 3$ db.

Another experiment for testing the loudness of a sound was devised by A. H. Davis, which gives a measurement of noise in decibels. A tuning fork is struck in a standard manner, and the time is noted that it takes the sound of the fork to fall to the same loudness as that of the noise under observation. To facilitate this measurement, the fork is moved to and from the ear so that it is alternately louder and softer than the noise. It is also necessary to calibrate the fork to ascertain how many decibels its initial intensity level is above the threshold and also to determine its rate of decay in decibels per second. For example, suppose the fork when first struck is 90 db above threshold and it decays at the rate of 1 db per sec; then, if it takes the fork 30 seconds to fall to the loudness level of the noise under investigation, the noise level of the latter is $NL=90-30\times 1=60$ db.

Direct estimation of the reduction of sound may be made by listening to a phonograph record prepared by the Bell Telephone Laboratories that reproduces sounds that are reduced various numbers of decibels. A reduction of one or two decibels is difficult to detect, but five or more decibels reduction produces an effect that can be noticed.

In conclusion, the speaker expresses the hope that the topics and experiments discussed will be suggestive to teachers of science and mathematics, and that students, in turn, will be stimulated to do further work in acoustics.

By far the greater part of the time actually spent in learning, above the primary school, is wasted because of poor instruction by teachers ignorant of their subjects.

—*David Eugene Smith*

"SELLING" ELEMENTARY SCIENCE

By Gordon MacLeod Taylor
Denville Township Public School, Denville, New Jersey

When an elementary school teacher decides on his own initiative that it is time to introduce science into his curriculum, he is at once faced with three problems of salesmanship. First he must sell the idea to his superior officer, the supervising principal, at least to the extent of securing permission to use some small amount of class time for the subject. Next he must sell the subject to the pupils. Finally the public and its representatives, the Board of Education must be brought to a realization of the value of the subject, in order that money may be made available for the purchase of desirable equipment, once the course is established.

Since the spirit of modern education welcomes experimentation, no great problem should be involved in securing permission to try the thing out, particularly if the teacher announces that he will personally furnish all the needed apparatus for the first two years, and withal use demonstration experiments rather than a set of textbooks as the heart of his course. Naturally he will need reference books, but if the school lacks such material, local, county and state libraries can usually be called upon for it.

Having secured official approval, the teacher must then plan his course. At this stage of the game, the writer found it convenient to divide the subject matter of the seventh and eighth grades into six large units. To save unnecessary labor in setting up demonstrations and preparing lesson plans for different units in these grades, the course was given on a two-year turn-over basis. After all, one unit presents little more difficulty than another, and the teaching technique is adjusted to the class in hand at the moment, so it makes little real difference which unit is presented first.

The units are divided into from four to ten topics for each of which a mimeographed outline sheet is prepared. In general the features of these sheets are:

1. Problems—in question form, the answers to which are the important principles of the topic.
2. Spelling words—an understanding of which will be needed to make possible the study of the principles.

3. Study questions—for pupils to use in testing their grasp of the ideas of the topic.
4. Suggested activities—of varied types to allow for individual differences in choosing "homework."
5. Reference list—by book and page to aid pupils in finding book descriptions of the principles studied.

As for selling the subject to pupils of this age level, nothing more than an enthusiastic teacher, a snappy demonstration and an opportunity to repeat the experiment with his own homemade equipment is required.

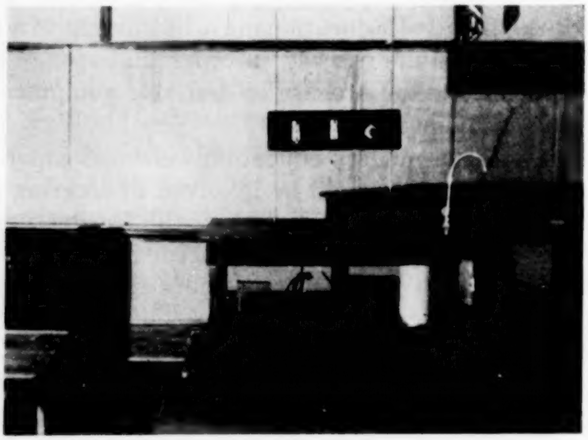


FIG. 1. Homemade Demonstration Table. Front view with display board in place.

Although the procedure varies from topic to topic, in general the sheets are passed out, the problem discussed, and when the class seems to understand what the topic means, the teacher gives demonstrations to illustrate the principles involved in the answer of each problem. These are then thoroughly discussed. Two periods a week are thus used, while two additional periods are provided for the use of the reference books and individual work by the pupils. When the work outlined on a sheet has been completed, a test including the spelling words and questions of either objective or essay type is given. Marks are based on the central tendency modified by the teacher's judgment.

From the foregoing it might seem that the teacher had assumed a tremendous obligation in agreeing to furnish all needed apparatus for the first two years, but the writer found that by

dint of hard labor and a keen sense of the value of junk piles, he was able to keep the cost well under ten dollars for the whole time. The work of constructing the more difficult pieces of apparatus is much simplified when the school has a well equipped industrial arts shop; however most of the writer's equipment was made in his cellar workshop with ordinary tools found in most homes.

To be of any value, demonstration experiments must be performed in such a way as to be visible to all pupils, so a suitable demonstration table is perhaps the first thing needed. Doubt-

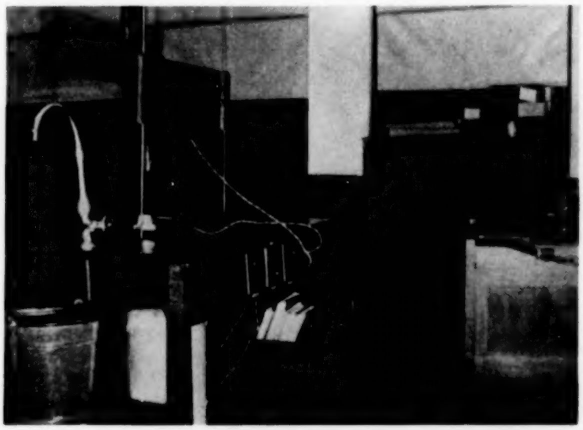


FIG. 2. Homemade Demonstration Table. Rear view showing water system and electrical outlets.

less the sky is the upper limit as to the cost of such a piece of furniture, but the lower limit might well be the one pictured herewith. It was built from scrap lumber, is 40 inches high, four feet long and two feet wide. Perhaps it is not a thing of beauty, nor should one be willing to consider it a joy forever, but for the all important first two years it serves its purpose admirably. In fact the one pictured is still in use as an extra, although the department has graduated to a fine big commercial table.

Doubtless we all agree that such a table should contain electrical, gas and water outlets. The first are easily provided by means of ten cent store switches and receptacles connected to any light socket by means of extension cords. If the room ventilators operate on direct current generated in the building by a motor generator set, it is possible that up to five ampere

loads may be plugged in on that circuit when such current is needed, hence the two cords on the table in the picture.

Water supply is no unsurmountable obstacle even with a portable table. The system pictured consists of a ten gallon pressure tank into which water is forced from a faucet in a lavatory, by means of the hose. A valve is then closed, the hose released and the table carried bodily back to the classroom. The air compressed above the water then serves to supply about fourteen quarts of water under good pressure, as needed. A pail does duty as a sink, and is to be preferred to a more elaborate

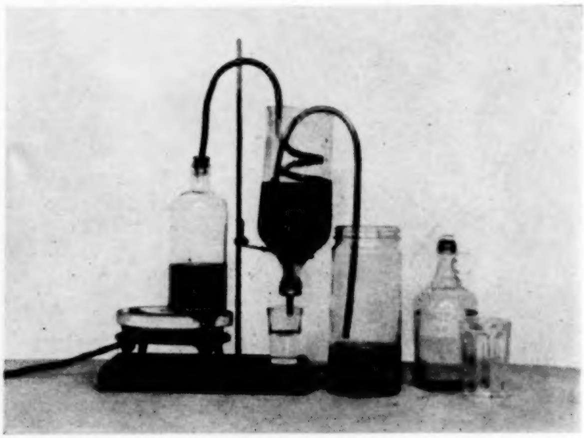


FIG. 3. Still Outfit. Made from bottles and copper gas line tube from junked auto.

built-in waste tank which might be forgotten until it overflowed. Incidentally, practically all pipe, valves and fittings were from the discard heap, as was the tank.

Gas connections are hardly possible until there is a budget provision for science needs, but alcohol lamps made by putting rolls of cloth into the necks of small bottles of alcohol, and an inexpensive electric hot plate pinch hit quite well.

Many of the demonstrations themselves require nothing more complicated than tin can lids, jelly glasses and bottles. For example the distillation outfit pictured uses a pint mouth wash bottle as its boiler. Although visitors have been waiting expectantly for the past four years for it to crack when the coil of the hot plate became red, to date it is still doing its duty without catastrophe. The condenser tube or worm, as a moonshiner

would call it, once served as a gas line on someone's car. The water jacket is a vinegar bottle minus its bottom. The water is siphoned out of the jacket and cool water is poured in as needed to keep the coil cold. The amount of distilled water shown in the tumbler under the coil was produced in about fifteen minutes.

And just a tip about cutting the bottoms from bottles; there are all kinds of directions for doing it. When you have tried them all unsuccessfully, this may save the day. Pour water

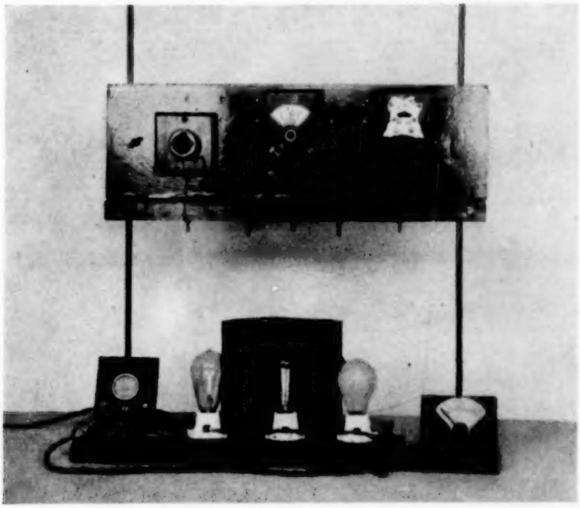


FIG. 4. Current Measuring Devices. Model of a solenoid ammeter. Hot wire type of meter. Automobile ammeter.

enough into a pan so that when you set your bottle therein, the water level will mark the point where it is to be cut off. Now rotate the bottle in the flame of a Bunsen or alcohol burner, being careful to warm it gently all the way around in the region of the intended break. When quite hot, set it in the pan of water, and if you are lucky, as you usually will be, the bottom will leave the top at the water level. The edge will be sharp, but this may be rounded off with a small corundum stone such as is used for sharpening knives.

Another set of apparatus, shown in the fourth illustration, traces its origin to the junk pile, with the exception of the toy motor, which was donated by a pupil who no longer wanted it. This group shows an idea for getting those flat pieces of elec-

trical apparatus up where the class can see them and how they are connected. Each unit is mounted on either a four inch square base or one four by six. By means of bolts and wing nuts, any desired combination of these may be quickly clamped in place on the display board which is supported by two ex-curtain rods. The rheostat is a relic of the storage battery radio days, as is the transformer in the center background. In former times it was a battery charger, but now its rectifier unit has been replaced by a "Ford" coil, and thus it has become a handy high and low voltage power pack. The old auto ammeter

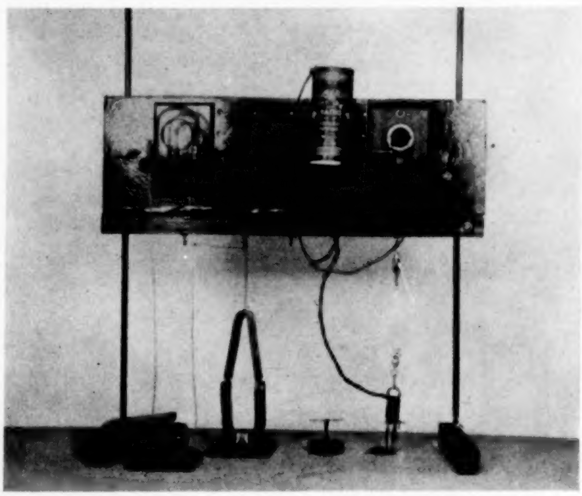


FIG. 5. Magnetism Demonstrations. Galvanometer showing current induced by magnetic field cutting coil. Law of repulsion and attraction. Homemade compass. Electromagnet setup.

illustrates the moving vane type of current measuring instrument, while the center device on the display board is a solenoid type meter. The coil consists of bell wire wound on a piece of brass tubing. As the current through the coil increases, the resulting increasing magnetic attraction draws a piece of bent nail up into the tube. This nail, being attached to the pivoted spool above revolves the spool and swings the brad pointer over the indefinitely callibrated dial.

The hot wire meter below also has a pivoted spool and brad pointer but these are turned in a somewhat different manner. From the extreme left end of the board, a piece of fine wire from an old auto generator cut-out coil passes up over and twice

around the spool. Its other end is attached to an elastic band which keeps it tight. By means of the lamp bank, the sockets of which were salvaged from a scrapped electric sign, varying amounts of current are sent through the fine wire, which is thereby heated more or less. The hotter the wire the more it expands, and the more the spool is rotated as the elastic band takes up the resulting slack.

The magnetic effects apparatus needs little comment. The permanent magnets are from an old loudspeaker and an old model T Ford, more evidence of the value of the junk heap. Any class can be provided thus with magnets enough to go around without any financial burden to anyone. The tangent galvanometer which is connected to show that a current is generated when magnetic lines of force cut a coil of wire, is made from an old radio coil, a compass needle from a ten cent compass and the glass cover from some old ornament. The compass needle might have been made by soldering a piece of clock spring to a binding post nut and balancing the whole on a sharpened nail. That is the construction of the compass in the right foreground.

To many who are accustomed to seeing elaborate and expensive laboratory equipment, these simple devices probably appear as merely the junk from which they were made. However they have proved the means of establishing, "selling" if you will, the idea of science as a vital subject in the school where they are used. The effect upon the pupils, too, is good, as it shows them that science is not necessarily confined to the rich or the learned, but is something in which any child can find a hobby.

LONG WORDS IN CHEMISTRY

There seems to be a perennial fascination in trying to discover the longest word in the language. The longest word in Webster's New International Dictionary, *Second Edition*, is said to be *honorificabilitudinitatibus*, but this is "a pedantic nonsense word," meaning honorableness, which apparently owes its inclusion in the dictionary to the fact that it was used by Shakespeare, in *Love's Labour Lost*. Many of the long words of a more serious sort seem to have been contributed by science—words like *lymphangioendothelioma* and *pancreaticocholecystostomy*. Among the words which sound more like "plain English," a fairly good-sized one is *disestablishmentarian*. Perhaps the most staggering accumulations of letters are names of chemical compounds. The following highly technical terms, while not themselves entered in the dictionary, appear, for the benefit of experts, in definitions of chemical terms: *methyl-amino-acetyl-pyrocatechol*, 3-*acetamido*-4-*hydroxy-benzene-arsonic*.

SOME OF NATURE'S CURVES
II. Simple Periodic Motion

BY SUE AVIS BLAKE
3 Pollard Park, Williamsburg, Virginia

Suppose that a mass be suspended from the ceiling and set to swing in a circle and that one views this circular motion from a distance in the horizontal plane of the circle. The motion appears to be merely to and fro, straight line motion in a vertical plane. A two-dimensional motion, that of a circle, has been compressed, as it were, into a uni-dimensional motion. The suspended mass appears to swing to and fro in a straight line, its speed increasing to a maximum, falling to zero, then, with direction reversed, repeating. And what the motion appears to be is almost the motion of the end of the eccentric rod of a steam engine and it actually is the motion of a displaced particle in a spiral spring, of a displaced particle in any free elastic body. The motion is simple periodic motion, the motion of a particle movingunder force directed always towards apoint and varying inversely with the square of the distance of the particle from the point.

Now a body dropped from rest is acted upon by the gravitational center of force[1] which is situated at the center of mass of the earth. Were it not for the presence of the ground the body would travel directly to the center of mass of the earth and swing beyond it, overshooting the mark and then oscillating as a displaced particle in a coiled spring oscillates, coming finally to rest only because of a counter force. In the case of a falling body the counter force is the reaction of the ground which stops the falling body before it has completed a single oscillation. A falling body never arrives at the point towards which it hurries with ever increasing speed; instead the ground receives it. A body dropped from rest performs simple periodic motion or simple harmonic motion or would but for the resistance of the atmosphere. We are completely oblivious of the fact that the motion is simple periodic because the body's path to the ground is merely a small fraction of one single swing or oscillation.

To get some notion of the distances travelled in successive equal time intervals by a particle performing simple periodic

[1] In terms of the older physics.

motion, divide the upper semi-circumference of a circle into equal parts and drop perpendiculars from the dividing points onto a horizontal diameter. The intersections of this diameter with the feet of the perpendiculars drawn, starting from the left, mark the positions reached by the particle at the ends of the successive equal time intervals. There is a relationship between these distances—they are in arithmetrical progression. The same results are yielded by successive values of $s_2 - s_1$ in the equation:

$$s_2 - s_1 = \tfrac{1}{2}\, g\, (t_2^2 - t_1^2)$$

in which s_1, s_2 are the spaces passed over by a freely falling body, in times t_1, t_2 is time and g is the acceleration of gravity. If in this equation $t_1 = 0$, it follows that $s_1 = 0$ and we have the familiar formula for a body falling freely from rest:

$$s = \tfrac{1}{2}\, gt^2 \qquad (1)$$

We have also, in elementary physics, the formula:

$$f = mg \qquad (2)$$

in which f is force or, more specifically, weight; m is mass and g, as above, is the acceleration of gravity. This weight is the attraction between the earth and some specific body, but the force between any two particles of matter may be mathematically expressed by the equation:

$$f = G\,\frac{Mm}{d^2} \qquad (3)$$

If M stands for the mass of the earth and d is the distance from the center of mass of the earth to the body in question, G being a constant of proportionality which depends in value upon the particular unit in which f is expressed, then f stands for the weight of the body in question, in equation (3) as in equation (2). Comparing equations (2) and (3), we see that

$$g = G\,\frac{M}{d^2}$$

and this we are prone to lose track of, that is, we are likely to forget the origin of the g in equation (2)—remembering the origin we remember also that a freely falling body is performing motion like that of a displaced particle in a coiled spring.

Suppose that after observing a suspended mass swing in a

circle where it seems to vibrate to and fro across a diameter we take up such a position that it appears to swing across the diameter at right angles to the first one. There is nothing to distinguish the present appearance from the former, here also it seems to be a to and fro motion in a straight line but the vertical plane in which it now swings is perpendicular to the previous plane. Consider the converse;—suppose a particle is actually performing simple periodic motion as this mass appears to be, or is merely swinging due to a shove, and that we give it a perpendicular shove just as it reaches one end of a horizontal swing. The mass is now simultaneously urged by two perpendicular forces, each force varying inversely with the square of the distance of the mass from its position of rest. How then does the mass move? This is precisely how to make a mass suspended from the ceiling swing in an ellipse, or, in the rare event of two perpendicular shoves being precisely equal, in a circle. If one perpendicular shove is greater than the other the path is an ellipse with the major axis in the direction of the greater shove. If the periods of the oscillations compounded are precisely equal the path of the mass, whether an ellipse or a circle, persists, but if there be ever so slight a divergence in period the path passes through a succession of forms as is shown by figure 1. This figure represents a half cycle of change. The succession of figures occurs because the oscillations due to one shove gain on those due to the other shove, giving paths which are due to combinations of all gradations of phase.[2]

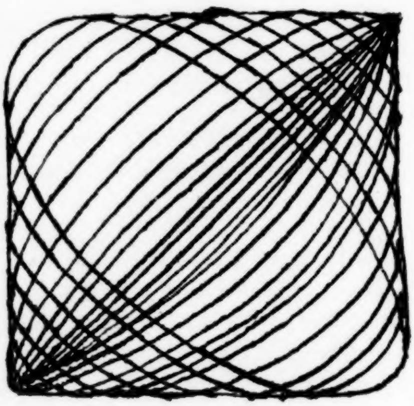


FIG. 1

[2] Phase is the position of a particle with reference to the part of the vibration already performed.

To show how closely pendular motion is related to simple periodic, and this non-mathematically, suppose that a mass suspended from the ceiling is moving in an ellipse which is not a circle and that one views this motion from a distance, observing the sweep through the major axis. One may no longer speak of viewing the sweep in the plane of the curve because now, although the mass appears to swing to and fro in a vertical plane, it does not move in a straight line but sags a bit in the middle of its course. If the minor axis of the ellipse in question becomes zero the sag is a maximum and the system as observed becomes a pendulum sweeping through an arc in a vertical plane. Similar to this motion is that of a child's swing, of a vibrating rod held firmly at one end, of a prong of a sounding tuning fork, of a stalk of grain over which the wind blows.

Geometrically the group of conics have this characteristic in common: in any one of them the distance from a point on the curve to a fixed point called the focus bears a constant ratio to the distance from the point on the curve to a fixed line called the directrix. This fixed ratio is called the eccentricity of the conic. The eccentricity of all parabolas is unity, the word "parabola" coming from a Greek word signifying "equality." The ellipse has eccentricities ranging from zero to one, the word "ellipse" being derived from the Greek word for "deficit." On the other side of the parabola, according to this mode of classification, lies the hyperbola with eccentricities greater than one, its name signifying "excess."

The paths of all the planets of our solar system are ellipses with eccentricities close to zero,[3] that is, the paths are very nearly circular. The orbits of recurrent comets are ellipses. An elliptic orbit of eccentricity approaching unity would, of course, have a period of almost infinite duration. The first part of its path would be almost indistinguishable from a parabolic or even from a hyperbolic track. See the first paper of this series—"Conic Sections" (March, 1936). Whether or not there are comets which depart from elliptic paths and follow parabolic or hyperbolic courses is as yet unknown.

[3] "The orbits of the planets are all ellipses with moderate eccentricities ranging from 0.007 for Venus to 0.206 for Mercury." Fath's *Elements of Astronomy*, p. 140.

SOME SUGGESTIONS IN THE TEACHING OF INHERITANCE IN SECONDARY SCHOOLS

I. Breeding experiments with animals and plants

By Lloyd W. Law
Bussey Institution, Harvard University,
Forest Hills, Boston, Massachusetts

Several years ago the author suggested (1) that one of the objectives of a high school biology course should be to secure for the pupil "an appreciation of the phenomena of inheritance in plants and animals." Too often the secondary school teacher is content with covering the subject of genetics as briefly as possible with the result that the treatment is superficial and confusing. The students are introduced to such terms as chromosome, gene, dominance, law of segregation, law of independent assortment, and in most cases the full significance of these is not recognized. Consequently there is a failure to realize the main objectives in a study of inheritance. It seems to me that if secondary school instructors had at their disposal concrete examples as a means of illustrating inheritance, the difficulties in its study would largely disappear. It is the object of this paper to describe some illustrative material that can be utilized in high school and private school laboratory work and for demonstration purposes. Some of the suggestions to be made call for ability beyond that of the average secondary school pupil, especially the suggestions involving chromosome studies; however these can be used to advantage in demonstrations, and may also be available to individual students of unusual ability or maturity of mind, or may be capable of incorporation in special projects. Instructors in teachers colleges and normal schools may find such material beneficial.

Breeding Experiments with Drosophila

The fruit fly, Drosophila, is advantageous for illustrating the principles of dominance, segregation, and independent assortment of factors because its culture requires very little space, the time for production of a new generation is only a matter of weeks and the cost is very reasonable, however it is disadvantageous in that the animal is small, and the identification of some characters will offer difficulties to high school students. Only characters easily recognizable should be employed. The materials needed for crosses include

(1) half-pint milk bottles for breeding jars
(2) cotton for stopping the ends of bottles
(3) small vials for isolation of pupae
(4) ordinary glass tumbler and a funnel to fit tightly into the glass—for etherizing flies
(5) ordinary hand lens or dissecting microscope

Drosophila food should be placed in the bottom of milk bottles. For a high school class the following recipe for preparing the food may be followed. It will provide sufficient food for 36 half-pint bottles.

corn-meal	250 grams
molasses	338 cc.
water	1875 cc.
agar	37.5 grams

Heat the water and agar together. After this is in solution, add the molasses and corn-meal and cook thoroughly. Fill each bottle to a depth of about one inch with the warm food material. When it is cool and one is ready to put flies in the bottle, add 2 or 3 drops of baker's yeast in suspension in water. Drosophila cultures may be obtained from several sources such as the General Biological Supply House, Chicago, Ill., The Dept. of Genetics, Carnegie Institution, Cold Spring Harbor, Long Island, N. Y., or possibly from your State University.

The following crosses may be used to illustrate dominance and if carried into a second generation will also illustrate segregation.

(1) Brown eyed ♀ ×red eyed (wild) ♂
Red eyed (wild) ♀ ×brown eyed ♂
(2) Red eyed (wild) ♀ ×white eyed ♂
White eyed ♀ ×red eyed (wild) ♂

This second cross illustrates sex-linked inheritance in a striking way when carried into the second generation, and is interesting in being the identical cross which led T. H. Morgan to frame the correct explanation for sex-linked inheritance.

(3) Curved wing ♀ ×normal wing ♂
(4) Normal wing ♀ ×curved wing ♂

The genes for brown eye and curved wing are located on the second chromosome while the gene for white eye is located on the first or sex chromosome and its influence is therefore called sex-linked.

By segregation is meant the separation and redistribution of unit characters among the offspring of hybrid individuals. It is a constant feature of all inheritance. In order to illustrate this, collect the F_1 flies of the above crosses 1 and 3, and mate them inter se in a mass culture. When larvae appear in the food material and begin to pupate on the sides of the milk bottle, the parents should be removed so that they will not be confused with their offspring when the latter begin to hatch. There should be collected at least 100 flies in the F_2 generation in order that a close 3:1 ratio be obtained. Of the three characters mentioned brown eye, white eye, and curved wing all behave as simple Mendelian recessives to the wild type allels. A good 3d chromosome factor that may be used is "spineless," expressing itself by a conspicuous reduction of the size of bristles on the body.

To illustrate best Mendel's second law, the law of independent assortment, factors located on the second and third chromosomes respectively should be used. Some suitable crosses are

(1) Brown eyed ♀ ×ebony bodied ♂
Ebony bodied ♀ ×brown eyed ♂

Mate F_1 individuals of each cross inter se in mass culture, collect the F_2 progeny and make counts, noting four combinations of factors that appear (1) normal eye, normal body; (2) normal body, brown eye; (3) ebony body, normal eye; and (4) ebony body, brown eye. Since both brown eye and ebony body behave as simple recessives to their wild type (normal) allels there will be an approximate 9:3:3:1 ratio upon obtaining a large number of flies.

Another cross that will well illustrate this second law is

Spineless bodied ♀ ×black bodied ♂
Black bodied ♀ ×spineless bodied ♂

These experiments on assortment and recombination of factors occurring in F_2 and involving more than one factor pair, make it clear to the pupils how readily new character combinations are formed, and emphasize the importance of hybridization as a cause of increased variation. An understanding of this process thus makes it easy to control and predict the appearance of new types of plants and animals.

All factors located on the first chromosome will behave as sex-linked factors, because the male carries no functional factors

on the *Y* chromosome. It is thought that in the evolution of this chromosome the factors located thereon have become inert. Thus in a cross between white eyed ♂ and red eyed ♀, all F_1 flies are red eyed in both sexes, and when these are bred together, white reappears in one-fourth of the F_2 offspring, indicating that red and white eyes are due to an allelomorphic pair of genes, red (wild) as the dominant. However, of the F_2 progeny all of the females are red, while half of the males are red and half white. The white male has transmitted his white genes only to the grandsons. When a red eyed (normal) ♂ is mated with a white eyed ♀, however, quite a different set of results follows. Among the F_1 offspring all the females are red eyed and all the males white eyed. When these are mated together, the F_2 offspring consists of red eyed and white eyed individuals in equal numbers in both sexes. A typical sex-linked trait thus follows a peculiar type of criss-cross inheritance. Some other common first chromosome sex-linked crosses are

(2) Wild eyed (normal) ♀ × bar eyed ♂
Bar eyed ♀ × wild eyed (normal) ♂
(3) Normal bodied ♀ × yellow bodied ♂
Yellow bodied ♀ × normal bodied ♂

Breed the F_1 of each cross inter se in mass cultures.

A good procedure to follow in breeding flies would be

(a) After obtaining your stock, place each particular character to be tested in a separate bottle containing food. For best results the bottles should be kept in a small chamber slightly above room temperature.

(b) Use only virgin females. This entails the isolation of pupae in the small vials until time of hatching.

(c) Transfer one female to a new breeding bottle either directly or by first etherizing. If flies are etherized, make the transfer to the breeding bottle in a small paper cubicle. Add a single male. Always make reciprocal crosses. (Note: Females can be distinguished from males by their larger size. The abdomens of the males are more blunt and are entirely black at the tip.)

(d) As soon as larvae appear in the food, kill off the adults or transfer to another bottle. Upon hatching of the F_1 flies mate these inter se in a mass culture. Etherize some of the flies to note dominant characters. When F_2 larvae appear, kill off the F_1 flies. A hand lens will suffice, if a dissecting microscope is not obtainable, in the recognition of the characters studied.

Breeding Experiments with Mice

Mice are convenient to have in the laboratory for several reasons. Because of their ease in handling, short period of gestation (3 weeks), and rapid maturity (2 to 4 months), they can be used to advantage in the study of inheritance to illustrate the principle of dominance and the laws of segregation and independent assortment of factors. They can also be used for simple experiments on growth, such as the effect of vitamins on body weight, etc. Small wire cages or simply constructed wire cages can be used to keep mice in. Cover the floor of the cage with a layer of sawdust. Bread and whole milk make a good wet ration for mice, however such a ration should be supplemented by corn, oats, etc. Greens should be fed at least once a week. It is also possible to obtain a specially prepared food from any feed company. It is possible to obtain mice from the Jackson Memorial Laboratory at Bar Harbor, Me., from the Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, Long Island, N. Y., or possibly from your State University.

Suggestive crosses for illustrating segregation are

(1) *Albino* (*C*) × colored (c)
(2) *Black* (*B*) × brown (b)
(3) *Normal eye* (*dark*) (Pe) × pink eye (pe)

In each case the dominant character is italicized. The F_1 mice of each group should be mated together, and the F_2 obtained, if in large enough numbers, should closely approach a 3:1 ratio.

Typical dihybrid crosses for illustrating independent assortment of factors are

(1) Pink eyed, *Black* × *Dark eyed*, brown
(2) Dilute brown × (*Intense*) *Black*
(3) *Gray* (*agouti*) × brown

The F_1 mice of each cross when mated inter se will produce among fairly large numbers a typical dihybrid ratio of 9:3:3:1.

One disadvantage in the breeding of mice is that it entails waiting two or three months—or possibly longer—for final results; however the crosses can be started before actual work in inheritance is begun and can be used as demonstration material. The one outstanding advantage of mice over Drosophila is the very easy recognition of characters involved, which is of importance to high school students.

Experiments with Plants

A simple study in inheritance stressing dominance and segregation can be made upon ears of corn. Ears borne on F_1 plants, produced by crossing F_1 yellow starchy (containing recessive sugary) plants may be obtained from Mr. George S. Carter of Clinton, Conn. By counting the starchy and sugary grains on each ear, recording in a table for total numbers, it will be seen there is a very close approach to a 3:1 ratio. Starchy is dominant to the recessive sugary (shrunken endosperm). It is also possible to obtain from the same source ears of corn that can be used to illustrate results of a dihybrid cross, illustrating independent assortment of factors. The best ears are those obtained as a result of crossing sweet corn with starchy corn, one variety with white seeds, the other with yellow. The seeds actually studied are F_2 seeds (borne by F_1 plants) which will show a Mendelian segregation of white against yellow as well as starchy against sugary endosperm. So that for a sum total of seeds on a few ears of corn it will be seen there is a close approach to the ratio of 9 yellow, starchy:3 yellow, sweet:3 white, starchy:1 white, sweet—yellow and starchy being completely dominant over white and sugary.

A good experiment which takes little time and space is one in corn planting. Seeds for study of a single factor, such as color of the plant, can be grown in a simply constructed chamber, heated slightly above room temperature. Plants heterozygous for the albino (white) seedling character, if self-pollinated, produce seeds one-fourth of which on germination are colorless and soon die. Such seeds grown on sawdust make a good demonstration of a 3:1 ratio.

Graphically this cross can be represented by

$$\begin{array}{ccc} Ww & \times & Ww \quad F_1 \text{ plants} \\ \text{(green)} & & \text{(green)} \end{array}$$

$$1WW:2Ww:1ww$$

$$\begin{array}{ccc} 3 \text{ green} & : & 1 \text{ albino} \\ \text{seedlings} & & \text{(dies in time)} \end{array}$$

These seeds can be obtained from Mr. George S. Carter or possibly through your State Agricultural Experiment Station.

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A COMPARISON OF I.Q. AND ACHIEVEMENT IN PLANE GEOMETRY

By Vivian L. Hummer
Kansas State Teachers College, Pittsburg, Kansas

THE PROBLEM

Statements that success in geometry is dependent upon a certain level of intelligence are often encountered in educational literature. Some writers even go so far as to specify a definite level of I.Q. as a prerequisite to effective accomplishment in this field.[1] However, the author was able to find but little recorded data to support such views. It is the purpose of this investigation to supply experimental data bearing upon this point.

The specific purpose of the study is to compare intelligence quotients and achievement in plane geometry. In this connection, an attempt has been made to answer the following questions:

1. Is there a significant correlation between scores on intelligence tests and on objective geometry tests?
2. Are levels of ability in geometry bounded by specific I.Q. levels?

HISTORICAL

In an effort to obtain data bearing upon this problem, Symonds[2] directed a testing program involving schools in twelve states. The Terman Group Test of Mental Ability was given early in the year, in most cases in October, while the Schorling-Sanford Achievement Test in Plane Geometry was given three times: on December 1, March 1, and June 1. The average correlation between scores on the two tests was .59.

In Burbank and Pasadena, California, Lee and Hughes[3] tested 125 high school pupils in an effort to set up criteria for predicting success in algebra and geometry. In the latter phase of the experiment the following criteria were used: the Orleans Plane Geometry Achievement Test, the Lee Test of Geometric Aptitude, the Hughes Trait Rating Scale, teachers' ratings on

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[1] L. Thomas Hopkins, *Curriculum Principles and Practices*, Chicago, Benjamin H. Sanborn & Co., 1931, pp. 108–9.

[2] Percival M. Symonds, *Ability Standards for Standardized Achievement Tests in the High School*, New York, Bureau of Publications, Teachers College, Columbia University, 1927, pp. 2–16.

[3] J. Murray Lee and W. Hardin Hughes, "Predicting Success in Algebra and Geometry," *School Review*, 42, 1934, pp. 188–96.

mathematical ability, the Kuhlmann-Anderson Intelligence Test, and the Terman Group Test of Mental Ability. The correlation between Kuhlmann-Anderson intelligence quotients and achievement scores was .54, while the Terman intelligence quotient gave a correlation of .44 with the achievement test.

Cooke and Pearson[4] gave several tests in two groups of Mississippi high schools in an investigation which had as its goal the prediction of achievement in plane geometry. Among others, they gave, at the opening of the school year, the Terman Group Test of Mental Ability, and at the close of the year, the Columbia Research Bureau Plane Geometry Test. The correlation between the scores on the two tests was .666 for Group I and .400 for Group II.

PROCEDURE

The data of this study were obtained in the plane geometry classes of the Senior High School at Joplin, Missouri. The classes were composed of 173 tenth-year students who had completed 8½ months of study in plane geometry. The pupils were grouped heterogeneously in seven classes, two instructors teaching two classes each, and a third teaching three.

Of the 173 students taking geometry, 154 were available to serve as subjects in this investigation. It was impossible to use the data obtained from one individual, so the conclusions of the study are based on the test scores of 153 students.

The Otis Group Intelligence Scale, Advanced Examination, Form A, and the Columbia Research Bureau Plane Geometry Test, Form B, served as measuring instruments. All examinations were administered by the author and Dr. Paul Murphy. In order not to disrupt the general school program, the tests were given in each separate class. The Otis Group Intelligence Scale was administered the first day, May 7, 1934, while the following day was given over to the administration of the Columbia Geometry Test.

RESULTS

Distribution of Scores. The means and standard deviations of the scores on the two tests are tabulated in Table I. It should be noted that the figures for the Otis test are in terms of raw scores rather than I.Q.'s. The mean score on the geometry test is probably somewhat lower than it should be owing to the fact that the

[4] D. H. Cooke and J. M. Pearson, "Predicting Achievement in Plane Geometry," SCHOOL SCIENCE AND MATHEMATICS, 33, 1933, pp. 872–78.

class periods were too short to permit the use of the time limits suggested by the author of the test. There is no reason for believing that this modification of the procedure affected either the reliability or validity of the test scores to any appreciable extent.

Relationship Between I.Q. and Geometry Scores. The relationship between the scores on the intelligence test and on the geometry test was determined by computing the Pearson product-moment coefficient of correlation between them. The correlation is $.58 \pm .036$, indicating a definite relationship between intelligence and achievement in geometry.

As test six of the intelligence test is concerned with geometric figures, it occurred to the experimenter that this one test might account for an unduly large part of the relationship found between the scores on the two tests. It was found, however, that

TABLE I
SCORES ON INTELLIGENCE AND GEOMETRY TESTS

	Mean	S. D.
Otis Intelligence Test	153.25	22.96
Columbia Geometry Text	29.92	13.16

the correlation between the geometry test scores and the scores on the Otis examination, exclusive of the scores on test six, was $.53 \pm .039$. Apparently test six plays no more than its fair share in determining the relationship between the two sets of scores.

Quartile Rankings. In an attempt to shed some light on the second problem of the investigation, *i.e.*, whether levels of ability in geometry are bounded by specific I.Q. levels, the scores on the geometry test were ranked from high to low, and divided into quartiles by the use of an accepted formula.[5] The I.Q. of each student was then placed opposite his geometry score, and the mean and standard deviation of the intelligence quotients included in each quartile were calculated. The results of these computations, as well as the reliability of the differences between the means of the various quartiles, are contained in Table II.

The results contained in Table II indicate that there is a significant difference between the means of the first and second quar-

[5] Henry E. Garrett, *Statistics in Psychology and Education*, New York, Longmans, Green and Co., 1927, p. 22.

tiles, and also between those of the third and fourth quartiles. The difference between the means of the two middle quartiles, however, is so small as to be of questionable reliability. Apparently the differences are significant only at the extremes. Additional support for this statement is contained in the fact that the difference between the means of the first and fourth quartiles (12.50) divided by the standard error of the difference yields a critical ratio of 6.5, which is even more highly significant than the differences between any of the adjacent quartiles.

In spite of the fact, however, that two of the three differences indicated in Table II are significant, it is evident that there is considerable overlapping in intelligence test scores from one quartile to the next. Assuming that $66\frac{2}{3}\%$ of the cases in each quartile fall between limits set by one standard deviation on either side of the mean, in the upper quartile this proportion of

TABLE II
QUARTILE RANKINGS OF I.Q.S

	Mean	S.D.	Difference of Means	Difference / S.E. Diff.
1st Quartile	117.61	7.56		
			4.68	2.92
2nd Quartile	112.93	7.00		
			1.63	1.00
3rd Quartile	111.30	7.72		
			6.19	3.97
4th Quartile	105.11	9.28		

scores falls between the limits of 110.05 and 125.17; in the second quartile, between 105.93 and 119.93; in the third quartile, between 103.58 and 119.02, and in the fourth quartile, between 95.83 and 114.39. These values show so much overlapping that they obviously mean very little so far as predicting specific levels of achievement in geometry is concerned. The force of this statement is even more evident when we remember that the above limits include only two-thirds of the cases in each quartile. The amount of overlapping would be even greater if we were to extend the limits to include all of the cases in each group. The fact is recognized, of course, that the consideration of other factors beside intelligence would increase the predictive value of our criterion.

Predicting Success or Failure in Geometry. While it appears im-

possible to set certain I.Q. limits bounding specific levels of achievement in geometry, there still remains the possibility of predicting gross success or failure in this field. An inspection of the scores composing the four quartile groups reveals some interesting facts bearing on this point.

In assigning school marks the lowest 7% of scores are usually considered as failures. In this study of 153 students the lowest 7% of scores includes 11 cases. Of the entire group examined, 14 individuals were found with I.Q.'s below 100. Of these 14, 5, or 36%, were among the 11 pupils with the lowest geometry scores. This is over five times the proportion that would be found in this group if pupils with low I.Q.s were found achieving promiscuously at all levels in geometry.

On the other hand, in the lowest 7% is included only one person with an I.Q. above 110. The I.Q.'s above 110 become increasingly frequent as one approaches the upper limit of the fourth quartile and passes into the other quartiles.

This very general inspection seems to indicate that failure in geometry is likely to occur if the I.Q. is below a limit lying somewhere between 100 and 110. The size of the correlation between geometry scores and I.Q.'s indicates that we would hardly be warranted in setting more definite limits than these.

SUMMARY AND CONCLUSIONS

In order to secure data with which to make a comparison of I.Q. and achievement in plane geometry, the Otis Group Intelligence Scale, Advanced Examination, Form A, and the Columbia Research Bureau Plane Geometry Test, Form B, were administered to 154 tenth-year geometry pupils in the Senior High School at Joplin, Missouri. An analysis of the scores of 153 individuals led to the following conclusions:

1. There is a significant positive correlation (.58) between scores on the Otis Group Intelligence Examination and on the Columbia Research Bureau Plane Geometry Test. This is true even when the section on geometric figures is omitted from the Otis test.

2. There is a significant difference between the average I.Q.'s of those individuals whose scores comprise the first and second quartiles of geometry test scores, between those making up the third and fourth quartiles, and between those falling in the first and fourth quartiles. The average I.Q.'s of the second and third quartiles did not show a reliable difference. It appears that

achievement in geometry can be differentiated only at the extremes of intellectual ability.

3. The wide range of scores in each quartile makes it seem inadvisable to attempt to set specific I.Q. levels corresponding to all the possible degrees of success in geometry. The evidence does indicate, however, that failure is likely to occur if the I.Q. is below a limit lying somewhere between 100 and 110. The broadening of our basis of prediction to include other factors beside intelligence would probably make a more definite prediction possible.

LAVOISIER (1743–1794)

By Sr. M. Agnese, N.D.
Norwalk, Ohio

Antoine Laurent Lavoisier, born in Paris, 1743, infused a new spirit into the body of science, chiefly by teaching it the uses of the balance and by his genius for scientific generalizations. Wealthy parents gave him a brilliant and thorough education. He studied mathematics and physics eagerly, enthusiastically. His power of analysis and synthesis were the equipment chemistry most needed at the time.

"Genius, being dynamic and not static in essence, always functions."[1] Lavoisier's keen intellect refused to accept the theory of phlogiston. "Balance in hand, he proved that in the economy of this universe nothing is lost—all is saved."[2] Shrewdly he elicited from the simple Priestley[*] the story of his experiment with gases, which he then used unfairly for his own advantage. He is called the "originator of the present ideas of combustion and chemical union—the founder of scientific chemistry."[3] Lavoisier realized the importance of language to a science; he delivered a master stroke by publishing in 1789—a date which marks the storming of the Bastile—"Traite Elementaire de Chimie," a textbook written in the language of the people. It destroyed the old notions that chemistry was something to be understood only by the mystics.

A staunch royalist, Lavoisier, the Fermier-Général (ex-farmer general), was condemned as a "cursed aristocrat." His pleadings for a respite of a few days in order to complete some researches, important to the good of humanity, fell on the deaf ears of the brutal revolutionist who condemned him to the guillotine. On May 8, 1794, France's period of political ferocity vented its fury on the fifty-two year old scientist whose "innocence and merit, private virtues and public services, amiable manners and love of friends, literary fame and exalted genius"[4] were unable to defend him.

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[*] See Jaffe, Bernard. *Crucibles*. New York: Simon and Schuster, 1930. Pages 65, etc.

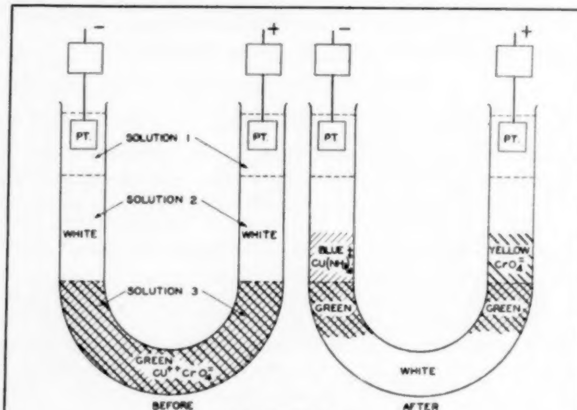
[3] Williams, R. P., *Elements of Chemistry*. Columbus: Ginn and Company, 1897. P. 1.

[4] (Rev.) M. S. Brennan, *What Catholics Have Done for Science*. Cincinnati: Benziger Brothers, 1887. P. 146.

DEMONSTRATING THE MIGRATION OF IONS

By Saverio Zuffanti
Northeastern University, Boston, Massachusetts

The concept of the migration of ions in solutions is clearly demonstrated by the following experiment, which we have used successfully for a number of years in our Inorganic Chemistry classes at Northeastern University. Equally satisfactory results have been obtained with either small or large classes.



DRAWING A

Drawing A illustrates how the materials are arranged in the U-tube and how they appear before and after the experiment has been performed.

Preparation of the U-tube

The following three solutions are required in the preparation of the U-tube:

Solution. 1. Ten grams of potassium nitrate are pulverized and dissolved in twenty-five milliliters of water.

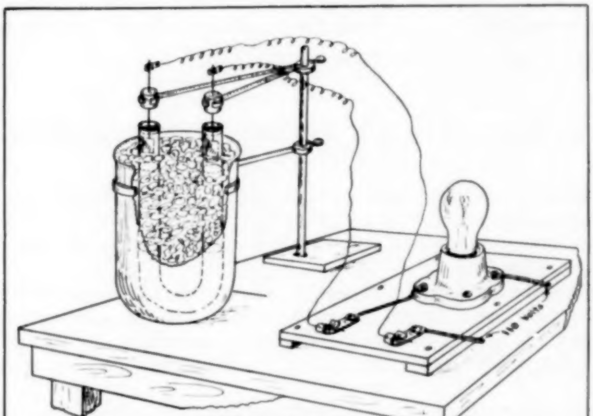
Solution. 2. Eight grams of Bacto-Agar are dissolved in 300 ml. of boiling-water and a few crystals of powdered potassium sulfate are then added. The solution is then cooled to about 50°F. amd 5 ml. of concentrated ammonium hydroxide are added. The cooling is necessary to prevent loss of ammonia by volatilization.

Solution. 3. Three grams of cupric chromate are added to 300 ml. of hot water and then glacial acetic acid is added in 1 ml. portions until the the solution becomes clear. If only a few undissolved particles remain, the solution may be filtered. The clear solution is then heated to boiling and 8 grams of Bacto-Agar are added with stirring. The heating is then continued until all of the materials are dissolved.

Solution 3 is prepared first and poured into a large U-tube (1″ diameter×8″ length) to the level indicated in Drawing A. After solution 3 has completely jelled, solution 2 is prepared and poured into both arms of the U-tube to equal heights. Finally after solution 2 has solidified, solution 1 is added to both arms. For best results the solutions should be prepared shortly before they are to be used; otherwise, solution 2, which is originally white, turns dark.

Operation of the Experiment

Drawing B illustrates the set-up of the equipment. The prepared U-tube is placed in a 2-liter beaker which is filled with an ice and water mixture. The electrodes, consisting of two small



DRAWING B

pieces of platinum foil supported by platinum wire, are inserted below the surface of solution 1. The platinum wires are held in place by cork stoppers clamped to a ringstand. The source of current may be a 110-volt D.C. line. A 250-watt bulb, connected in series with the electrodes, serves as a means of regulating the flow of current and as a switch for turning the current on and off.

It is advisable to screw the lamp down and start the experiment shortly after the class begins. Within five or ten minutes a decided change becomes apparent. Solution 2, on one side, becomes blue because the Cu^{++} ions migrating into this region combine with the free ammonia to form the blue $Cu(NH_3)_4^{++}$. The ammonium hydroxide effectively deepens the blue so that

it becomes visible to the class. Solution 2 on the opposite side becomes yellow through the migration of the $CrO_4^=$ ions into this region. As the experiment progresses, these colors can be seen to rise up into the solution 2 region until one side is entirely blue and the other is entirely yellow. At that time the lower region of solution 3 becomes white because of the disappearance of the green $CuCrO_4$.

If time permits the instructor may now reverse the poles by pulling out the plug and re-inserting it with the prongs interchanged. The blue $Cu(NH_3)_4^{++}$ ions and the yellow $CrO_4^=$ ions will then return into the solution 3 region where the green color will re-appear, leaving the solution 2 regions again colorless or white.

The time required in assembling the entire experiment, ready for classroom use, is one-half hour. If the above instructions are followed closely the experiment will work without fail.

ADVISE MASSAGE BEFORE COUNTERSHOCK TO REVIVE HEART

A method of reviving hearts, that should prove valuable in surgical operations on the heart, was reported by Dr. C. J. Wiggers, Western Reserve University School of Medicine, at the meeting of the American Physiological Society.

The method makes use of massage and a weak electric current. Both of these have been used before to revive hearts, but the new and important point reported by Dr. Wiggers is the order in which the two procedures are carried out. Massage first, then use countershock, Dr. Wiggers advises.

Passing an electric current of about one ampere strength through a heart that is fibrillating will stop the useless twitching of single muscle fibers known as fibrillation and make all the fibers contract together in a beat strong enough to pump the blood out into the body. This was found by other scientists in previous research. The method, known as countershock, has been used to revive animals shocked by low-voltage electric currents which are one factor that causes fibrillation.

Dr. Wiggers and associates tried the electric shock method of reviving hearts that were fibrillating because of stoppage in the heart arteries. They found that the method worked, provided the stoppage of the artery was removed and the fibrillation had not lasted more than 2 or 3 minutes. After 5 to 8 minutes of fibrillation, the electric current did not stop the fibrillation and revive the failing heart even when massage of the heart and stimulating drugs were tried.

By massaging the heart before rather than after passing the electric current through it, Dr. Wiggers was able to revive 40 out of 47 dogs whose hearts had been fibrillating for as long as 5 to 7 minutes. No drugs or chemicals were needed.

"The method should prove of value in revival of exposed human hearts that fibrillate accidentally during the course of cardiac operations," Dr. Wiggers stated.

EXTENDING THE RANGE OF USEFULNESS OF THE TRIPLE-PURPOSE MICRO-PROJECTOR

By H. O. Burdick
Alfred University, Alfred, New York

In spite of the fact that much has been written about micro-projectors recently, the writer wishes to describe the "depression" projector which has been in service in his laboratory for the last two years. This apparatus has proven to be so efficient it was thought that others might be interested in it.

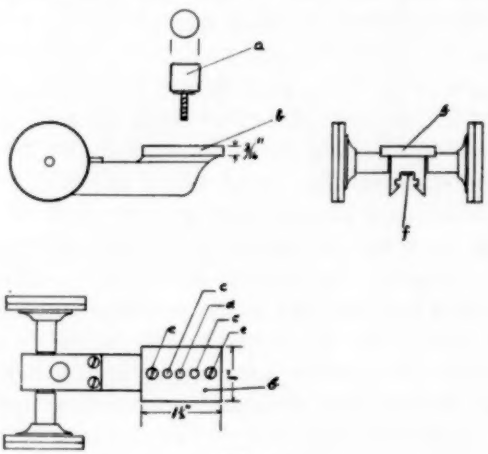


Fig. 1

The accompanying figures illustrate the essential set-up which consists of a Bausch and Lomb Triple-Purpose Micro-projector with the usual objective and mirror replaced by a part of an old brass microscope, a Bausch and Lomb model V or VO. The brass arm between the pillar and tube of the microscope was cut in two and the tube side drilled for the two screw holes (Fig. 1, c,c) so that a small solid brass plate (b) could be fastened against the arm. This brass plate supports the microscope tube on the bed of the projector and fits snugly into the track to prevent side-play. A thumb screw (Fig. 1, a) fastened into the threaded hole (Fig. 1, d) of the brass plate from the lower side of the bed allows adjusting and dismounting. Special care must be taken in cutting the arm and drilling screw holes so that the microscope tube will be in perfect alignment with the light rays from the condenser. Non-threaded holes (Fig. 1, c,c) can be

bored through the plate (b) and into the pillar of the microscope so that when the thumb screw (a) is removed the apparatus may be reassembled (Fig. 3) for use as a microscope with the plate still in position. The screw heads (Fig. 1, e, e) must be flush with the plate and the heads of the screws for reassembling the microscope must be countersunk in the track (Fig. 1, f).

The objectives consist of the split objective which is furnished with the original Triple-Purpose Micro-projector and a Spencer divisible 16–32 mm. stirrup objective. Both are easy to operate and give good definition to the projected objects. With these four objectives and two more eyepieces a wide range of magnification may be obtained. A small mirror (Fig. 2, g) is tilted up out of the way during horizontal projection but may be lowered to make drawings of the object shown. If the projected image is carefully shielded from the room light by a three-sided box several students may study the demonstration at the same time.

The mirror is especially useful when projecting live forms. The micro-projector is placed in an upright position so that the stage is level. If a special water cell is not available for heat absorption a Syracuse watch glass partly filled with water may be substituted. The slide with living material should rest on the watch glass above the water level. This water will gradually heat but may be changed by pipette or siphon. When such forms as hydras are shown expanding and contracting and feeding on Daphnia or small ostracods, the student interest is indicated by the lively discussion which accompanies the demonstration.

At first, we used a small room near the laboratory which could be darkened for projection but there was too much time lost in parading to and from the demonstrations. The next step was to place the machine in a large closet which opened into the laboratory. A window (Fig. 2) 18×18 inches was cut in the upper panel of the closet door and a translucent screen on a wooden frame built between the projector and the door, as shown in Figure 2. White tracing cloth (Eugene Dietzgen Co., No. 142) with the duller side towards the audience is excellent for this purpose. Dark cloth curtains were hung on 30 inch iron brackets (Fig. 2, k) to cut off much of the side light from windows. When the projector is not in use the curtains can be swung out of the way. To prevent the projector from being knocked off the table in the dark, it was fastened by a thumb screw (Fig. 2, m) to the board (Fig. 2, o) which in turn was bolted to the bench on which the apparatus rested by a thumb

screw in a slotted groove so that the projector could be shifted in position. The hinged board (Fig. 2, o) facilitates a change from the horizontal to the vertical position. The whole board

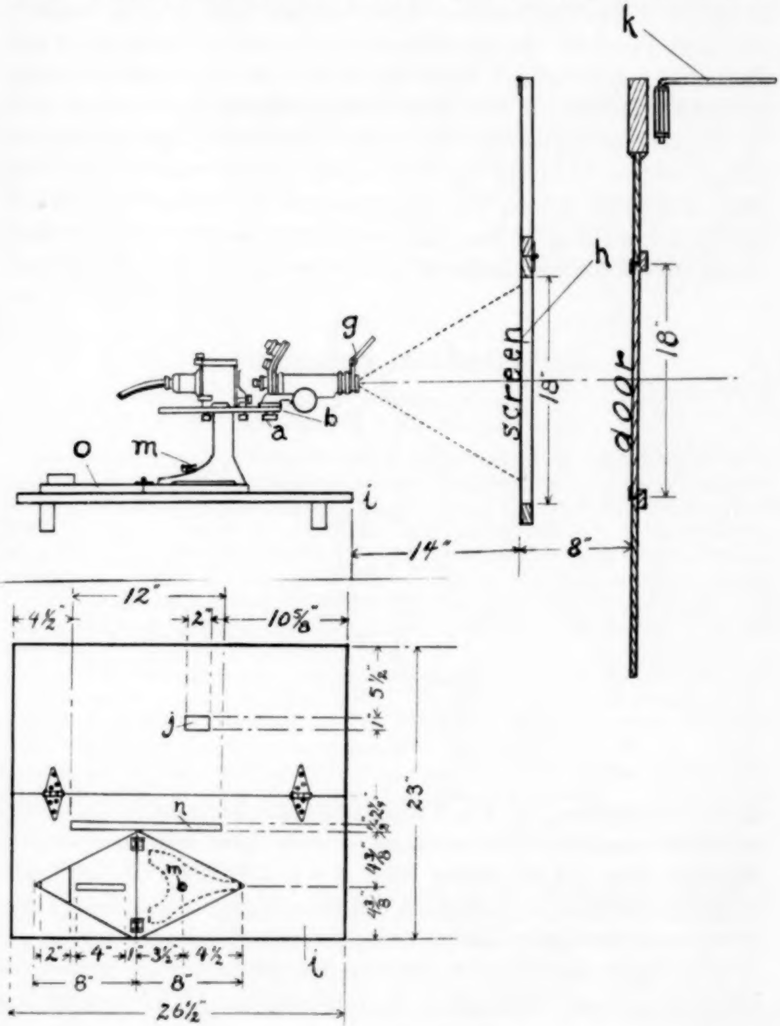


FIG. 2

(Fig. 2, i) may be hinged to swing back out of the way. An upright post will support the projector and a small strip (Fig. 2, n) may be needed to hold everything in position.

With this present set-up the instructor can be in the dark room, operate the projector and point out the various features

of his demonstration by the clear shadow of his pencil or other pointer. The lamp in the projector is controlled by a switch which is easily reached from either the laboratory or the machine in the dark room. The students gathered in front of the screen can see the projection clearly and the instructor and students can continue their discussion as the demonstration proceeds. This use of the projector for microscopic objects is of far greater pedagogical value than displaying special objects under microscopes set up in the laboratory where some one may accidently knock the object out of the visual field. When others are waiting in line, the more self-conscious student may make such a hurried inspection that he misses the real purpose

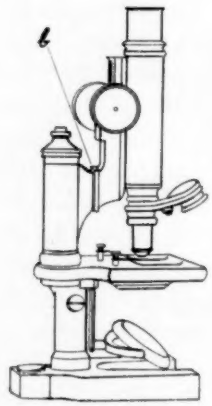


FIG. 3

of the demonstration. I feel sure that there are many instructors who have had students come away from these microscopes saying that they did not know what it was all about. By contrast, with this method each student has the opportunity to see everything and can have his questions answered immediately.

The writer would not substitute the projector for individual microscope work but when certain studies of live forms are shown or several objects are to be compared or a review or quiz given this projector is a valuable teaching aid. Then too, present budgets do not permit the purchase of many microscope slides of a kind but with this apparatus a special collection of demonstrations slides may be purchased and new material introduced. For example, the author wished to compare the value, for laboratory purposes, of Clonorchis sinensis, the Chinese liver

fluke and the sheep liver fluke. A few excellent slides purchased from Powers and Powers, projected before whole laboratory sections proved Clonorchis a superior form to introduce the study of flukes. In another exercise, the general embryology of the chick was studied in the freshman group by means of whole mounts. To purchase thirty slides of each stage shown was impossible but with excellent demonstration slides the exercise could be given. The quickened student interest and the clearer conception of embryological events prove, thus far, the efficiency of this method for general zoology. Mimeographed drawings of the material projected to be labeled by the students during the demonstration will frequently expedite and clarify the demonstration.

IN PRAISE OF MATHEMATICS

By J. S. Georges
Wright Junior College, Chicago, Illinois

The study of mathematics is apt to commence in disappointment. The vast and important applications of its principles, the theoretical interest of its concepts, the universality of its entities, the unchangeability of its laws, the preciseness of its operations, and the logical rigor of its methods, all tend to generate the expectations of the student to a speedy initiation into its mysteries. By its manipulations, he is told, man is able to solve the riddle of the universe, to weigh the remotest stars, to determine the size of an atom, to penetrate the hidden mysteries of nature and study its laws.

Yet this great science eludes the mental efforts of the beginner because its generalizations are transcendental, its discoveries are shrouded in the secrets of a unique language, to the deciphering of which he is told there is no royal road. In order to appreciate the rhythm of Milton, or the passion of Shelley one must have mastered the art of reading beyond the stage of having to spell the words. Even so in mathematics, in order to appreciate the beauties of its concepts, it is necessary to master the art of reading its peculiar language. It is the mastery of its language that is apt to discourage the beginner.

This disappointment, though significant, is but transient for even the high school student whose efforts are devoted primarily to the learning of the language of mathematics is forming the necessary adaptations for the understanding of its elementary laws and generalization, and for the appreciation of the beauties of its fundamental concepts. Attention to the technical processes does not altogether exclude the consideration of the general ideas.

The supreme ideas of mathematics as a science are being presented now as never before in their most obvious aspects, to be understood and utilized by the individual for his personal use, and by society for the advancement of scientific knowledge.

The student who is in possession of the fundamental ideas of mathematics has at his disposal a great body of scientific knowledge, a vast number of the essential facts of financial and economic sciences, and a keen understanding of many of the endless social problems.

SECTIONING A GENERAL PHYSICS LECTURE COURSE IN ORDER TO ADAPT INSTRUCTION TO ABILITY

By C. H. Long
Northwest Missouri State Teachers College, Maryville, Missouri

The study with which this paper is concerned was undertaken for the purpose of determining the most suitable basis for the division into two groups of the students in one of the new required general courses for freshmen and sophomores, Physical Science 1b (Physics), at State Teachers College, Maryville, Mo., so that instruction could be suited to ability. The investigation is based on the work of the students enrolled in the course in 1934–35. Though the investigation is concerned with the work of a single specific course (Physics), the conclusions reached have an application by analogy to other courses, especially science courses, and should be of general interest.

In this study a division of the students in Physical Science 1b was sought that would satisfy the following conditions: (1) The class is to be divided into a superior group and a slow group to the end that instruction may be better adapted to the capabilities and interests of the students, the slow group being offered only the minimum basic material, while the superior group is offered more advanced material and an enriched course. (2) The superior group is to comprise only E, S, and M students, while the slow group is to include only M, I, and U students, as graded on the normal curve, where E, S, M, I, and U have the usual meanings. It will be seen that this requires a division in terms of grades such that 100% of the superior group reach or excel the median ability of the slow group, while 0% of the slow group reach or excel the median ability of the superior group. (3) An initial division is desired that will hold at a minimum needed transfers from one group to the other by reason of inability to do the work satisfactorily or ability to handle more work. (4) The groups are to be as nearly equal in number as possible.

Several possible bases of division were investigated. These included division on the basis of: (1) whether or not the student had studied high school physics, (2) whether the student ranked above or below the median ability of the group in the freshman mental aptitude tests, (3) a composite grouping based on men-

tal test scores plus whether or not the student had studied high school physics, and (4) a composite grouping based on the work of the student in Physical Science (Phy. Sci. 1a) in the previous quarter plus whether or not he had studied high school physics.

The number of students enrolled in Physical Science 1b in 1934–35 was 105, but only the 102 students whose records were complete as regards intelligence scores and other data are considered in this study. The distribution of term grades shows an Med of 56.07, a Q_1 of 41.55, a Q_3 of 75.3, and a Q of 16.88, while the distribution of mental tests scores has an Med of 155.56, a Q_1 of 118.20, a Q_3 of 203.33, and a Q of 42.57. Both distributions approximate the normal curve, though both are skewed slightly toward lower scores, the skewing being slightly more pronounced in the case of term grades. However, the skewing is not sufficient to seriously affect results. The coefficient of correlation between term grades and mental test scores is $.64 \pm .04$.

Table 1 shows the results of the studies made of the grades given Physical Science 1b students to determine the most suitable method of sectioning. Study of the grades made by students who had studied high school physics (group 1a, 51 students) and those who had not (group 2a, 51 students) to determine the advisibility of grouping on this basis shows some superiority of the first group over the second in that 78.4% of the students in the first group reach or exceed the median grade (47.72) of those in the second group, while but 41.2% of the students in the second group reach or exceed the median grade (59.58) of those in the first group. However, an examination of these percentages shows that a large number of transfers will be necessary if the student's having studied or not studied high school physics is made the basis of grouping (for under the designated conditions for sectioning, to eliminate the need for transfers the percentages of one group reaching or exceeding the median ability of the other should be 100% and 0%).

But is the difference noted between groups 1a and 2a really a difference attributable to the study of high school physics, or is it perhaps due instead to varying degrees of ability as measured by intelligence tests? The answer to this question is found in a comparison of the distributions of intelligence scores for groups 1a and 2a. Inasmuch as these distributions show no significant

difference (Q_1, Med, and Q_3 being 118.35, 154.00, and 205.00 respectively for group 1a, and 116.87, 157.50, and 200.83 respectively, for group 2a) it is indicated that the superior performance of the students of group 1a over those of group 2a is really owing to their study of high school physics.

Could the students be satisfactorily grouped on the basis of their intelligence scores? Table 1 shows that the group of students having intelligence scores above the median for the group

TABLE 1

COMPARISON OF PHYSICAL SCIENCE 1B STUDENTS, STATE TEACHERS COLLEGE, MARYVILLE, MO., 1934–35, WITH RESPECT TO TERM GRADES IN THE COURSE TO DETERMINE THE BEST METHOD OF SECTIONING

Grades	Frequency							
	I		II		III		IV	
	Group 1a Studied H.S. Physics	Group 2a No H.S. Physics	Group 1b Above Median Intelligence	Group 2b Below Median Intelligence	Group 1c*	Group 2c	Group 1d**	Group 2d
130–140	1		1		1		1	
120–129		1	1		1		1	
110–119	1		1		1		1	
100–109	6		6		6		6	
90– 99	2	1	3		3		3	
80– 89	4	5	6	3	8	1	6	3
70– 79	8	1	7	2	7	2	9	
60– 69	3	13	11	5	6	10	8	8
50– 59	12	2	7	7	9	5	6	8
40– 49	9	11	4	16	6	14	6	14
30– 39	3	9	4	8	2	10	3	9
20– 29	2	6	1	7	1	7	1	7
10– 19		2		2		2		2

* Group 1c includes all students having intelligence scores above the third quartile and those having intelligence scores between the first and third quartiles who had studied high school physics. Group 2c includes all other students.

** Group 1d includes all students making an S or E in the work of the previous quarter in Physical Science (Phy. Sci. 1a) and those making an M who had studied high school physics. Group 2d includes all other students.

(group 1b, 52 students) tends to marked superiority over the group having intelligence scores below the group median (group 2b, 50 students), as 86.5% of the students in the first group reach or exceed the median grade (45.0) of those in the second group, while only 10.0% of the students in the second group reach or exceed the median grade (69.1) of those in the first group. These percentages are markedly more favorable than those obtained when the division is based on the study of high

school physics, and indicate that relatively few transfers will be necessary. Hence we may safely conclude that sectioning based on intelligence scores is reasonably satisfactory.

It seemed likely that a division based on both intelligence scores and the study of high school physics would afford better grouping than either method employed alone. Accordingly (see Table 1), a study was made of the grades obtained by students of groups 1c and 2c determined as follows: group 1c comprises all students ranking above the third quartile in intelligence scores together with those ranking between the first and third quartiles in intelligence who had studied high school physics, and group 2c includes all other students. The first group, numbering 51, shows pronounced superiority over the second group, also numbering 51, since the percentage of students in the first group reaching or exceeding the median grade (44.65) of those in the second is found to be 90.1%, while only 3.9% of the students in the second group reach or exceed the median grade (72.15) of those in the first group. Thus it is clear that this grouping shows a slight superiority, and one that appears to be significant, over that based on intelligence scores alone and proved to be the best investigated, showing percentages closest to 100% and 0% of those in one group reaching or exceeding the median grade of those in the other, thus indicating the need for fewest transfers and the most efficient separation into two groups.

A study was also made to determine the suitability of a second composite grouping based on the student's record in Physical Science (Phy. Sci. 1a—6 weeks of geography and 6 weeks of mathematics) in the previous quarter (instead of intelligence ranking) plus whether or not the student had studied high school physics. Groups 1d and 2d were determined as follows: group 1d includes all students making an S or E in Physical Science 1a together with those making an M who had studied high school physics, and group 2d includes all other students. Similar results would doubtless be obtained should the entire previous quarter's work be considered, or the work in any selected groups of studies. The first group numbers 51 and shows marked superiority over the second group, which also numbers 51, as the percentage of students in the first group reaching or exceeding the median grade (45.36) of those in the second group is 86.3%, while 5.9% of the students in the second group reach or exceed the median grade (71.67) of those in first group.

On the whole, this grouping possesses about the same merit as that based on intelligence scores alone, with a shade of superiority over the latter which is perhaps not significant.

CONCLUSIONS

1. Students who have studied high school physics tend to do somewhat better work in Physical Science 1b (Physics) than those who have not. The difference appears a significant one, as the intelligence scores of students who have studied high school physics and those who have not tend to follow essentially identical distribution curves. However, the study shows that division based on the study of high school physics is not very satisfactory, and will make necessary a large number of transfers.

2. Students having intelligence scores above the group median tend to do much better work in Physical Science 1b (Physics) than those having below median intelligence scores. Sectioning based on intelligence scores is, in the main, satisfactory, since the study shows only a moderate overlapping of the two groups and the need for relatively few transfers.

3. The best sectioning is obtained by combining intelligence scores and the study of high school physics. Of the several sectionings investigated, this method gives the least overlapping of the superior and slow groups and reduces the needed transfers to a minimum.

4. A good sectioning is also obtained by employing term grades in Physical Science 1a (work of previous quarter in Physical Science) in conjunction with the study of high school physics.

A NEW LABORATORY DESK

A new type of laboratory desk designed by Dr. Charles E. Maw, professor of chemistry, which makes possible both classroom and laboratory instruction in the same room has been recently installed in the organic chemistry laboratory at Brigham Young University. Four desks of this type have been installed in room 285, Education Building.

This arrangement makes possible the use of the demonstration type of instruction in which selected students demonstrate and discuss certain phases of various chemistry experiments before the group. This partly eliminates the routine type of laboratory instruction commonly employed.

The desks are so designed as to be high enough for laboratory purposes and yet low to be used as tables for writing. A hidden drainage pipe and two sinks on each desk eliminate the customary lead trough. Four water taps and two filter pumps have been provided for each sink. Shelf lockers eliminate the expense of drawers which are the most expensive part of such equipment.

METHOD OF ACCOMPLISHING LABORATORY WORK IN A SINGLE PERIOD*

By H. Clyde Krenerick
North Division High School, Milwaukee, Wisconsin

I do not wish it understood that I am here to advocate that all should use the single laboratory period instead of a double period for the teaching of physics. The purpose of this number on your program is, as I understand it, to help those who by force of circumstances or by decree have been, or may be, compelled to change from the double to the single period. It will be my purpose to cheer rather than condole; to cheer with the plea that it is not all misfortune, but that the single period has some advantages.

Personally I much prefer the single period because it makes possible at all times perfect correlation between the laboratory work and the classroom discussion, which correlation is absolutely necessary for my method of teaching physics. I am opposed to double periods because then the legitimate portion of the student's time to be devoted to one subject has been exhausted and no task can be assigned to him for outside or individual preparation. Long hours of home work has become a matter of serious concern. Eight periods of mental effort per day should be considered sufficient for growing youth.

In order to understand each other we will have to have a common language. We will have to agree on what we mean by student laboratory work. There is a great variety of laboratory methods. It might be well to describe the two extremes.

One extreme is often advocated by supervisors and professors of education in our state universities, or used perforce in schools where the equipment is meager, namely, the system of putting out one set-up only for each experiment, several experiments to be in progress at one time, worked by students in groups, from one to six weeks after the subject was demonstrated and discussed in class.

The other extreme is to have perfect correlation between the laboratory work and the classroom discussion. To have the laboratory work precede the classroom discussion and become a real or integral part of the teaching method. To have each

* Read at the Physics Section meeting of the Central Association of Science and Mathematics Teachers, Chicago, November 29, 1935

student, individually, perform each experiment demonstrating and introducing each new principle. To have the record of each experiment completed and checked in the laboratory.

For many years, like others, I used the first system. The university inspectors came ever so often and if we wished physics to be approved so that our school could be on the accredited list, we had to have a note book with the 35 or 40 standard experiments extensively written up and beautifully done. Just how it was done or who did it, the inspectors were, of course, not concerned.

But many of us were not satisfied. We wondered if the results justified the time and the expense. The amount of energy or thought expended by the majority of students working in a group is very questionable. Experiments that the students have seen and discussed at some previous time have lost their interest and will be to some extent mechanically performed.

Some instructors have concluded that the results of such laboratory work did not justify the time and expense and have turned to the teacher demonstration method. In my own department we have turned to the other extreme, to laboratory physics. Practically the entire course is built around experiments previously performed by the students working individually in the laboratory. For a large number of the experiments we have twenty-eight duplicate sets of apparatus so that all students work individually and on the same experiment. In the year they perform ninety experiments which introduce practically all of the principles and subject matter of elementary physics.

With this method more than half of the time must be spent in the laboratory. With a single laboratory and several physics sections, double periods for laboratory days is quite impossible. At North Division we have nine sections and eight periods. Rather than to change our system we have one section meet before school.

To save time, and for other reasons, the following day's assignment is written on the blackboard. The numbers of the articles or paragraphs in the text are indicated. If it is an assignment for an experiment the next day the numbers are underscored. I know that our unit system friends look at such methods of assigning work with disgust; but we claim that it is the unit system. Each laboratory problem, each day's assignment is a unit. I am still old-fashioned enough to believe in

the advantages of assigning a definite task to be done or accomplished in a definite time.

Tomorrow's task or assignment is seldom discussed in class. The instructor is not to get the student's lesson for him. We believe in rugged individualism rather than supervised study. Make the task simple and definite but make the student responsible. It does not matter how simple the task is, and most of our experiments or physics problems can not be made too simple, if the student accomplishes the task by his own unaided effort, it gives him a certain thrill or pride.

Some of our experiments are difficult so that only a few of the better students succeed. But that is no great misfortune. It leads to a little more intensive preparation next time, and many of the better students like the challenge of a difficult task. I know that this method is a little difficult for some students and that they are going to be lost a part of the time, but with our enforced mass education we can not have a special method for each individual student. We must use the method that gives the greatest good to the greatest number.

On laboratory days the students at once pass from the recitation room to the laboratory. They are not allowed to consult the textbook in the laboratory and they do not communicate. They have been instructed, and soon learn from experience, that they must make previous preparation. The instructions or directions for the experiment are intentionally so written that the student must have knowledge of certain fundamental facts given in the previous day's assignment. If he has not such knowledge he is soon lost and it is very evident. He knows that he is graded for each day's accomplishment and so a failure here is like a failure in a written test.

They are urged, and I believe that most of them heed, to study the correlated subject matter of the text as they read over the directions and computation for the experiment, so that when they come to the laboratory they will know definitely what they are going to do and how they are going to do it. This little feature of compulsory preparation is the strongest factor in the success of my system or the success of a single period experiment.

As one reads the different laboratory manuals there may not seem to be much difference; but compare the processes of thought and reason required of the student when using these two types of manuals, for illustration in the experiment on

specific gravities. The first type defines specific gravity; it gives a complete formula for computing from the data the specific gravity of a sinking object, of a floating object, and of a liquid. The second type gives the same general directions and uses the same general apparatus, but it does not define and it does not give the methods of computing results.

With the first type of manual the student does not need to make any preparation. All he needs to know is in the manual. He does not even need to think in the laboratory. He can mechanically follow the directions and mechanically substitute the specified data in the given formula and compute his results. With the second type of manual, where the necessary information is not given or not available in the laboratory, the student must inform himself as to what it is all about and how he is going to compute his results. This is what we mean by compulsory preparation. Surely the knowledge acquired by the student with these two systems is vastly different.

For the laboratory record we use a bound hard-covered note book. The manual gives a tabulation form for the record of each experiment. The students copy this tabulation on a left-hand page in their note books before coming to the laboratory. They are required to record their readings or data directly in the note book in ink. If a mistake is made it is not considered a sin. Brackets are placed around the part that is wrong and it is rewritten below. This may not make the most beautiful note book, but we prefer that it be a work book rather than a state-fair exhibit.

Some of the items in the tabulation are, of course, the results of computation. The indicated steps of this computation are recorded on the same line on the right-hand page. This aids greatly in checking the results and the methods of computation. The answers to questions or the conclusions called for in the manual are written underneath the tabulation. These statements are usually lettered so that the instructor knows exactly where to look for what he wishes to find.

When the student has finished his record he takes it immediately to the instructor for checking and grading. This will be started by the better students ten or fifteen minutes before the close of the period. With this universal and definite form of recording, the record can be checked in just a few seconds. If everything is acceptable the instructor turns to the index page. In the index two columns are left for the instructor's record

of acceptance and grading. One column is for the main experiment and the other for the optional part. We use a small stamp containing our initials and the grade given the work is indicated by how the stamp is placed in the column.

One thing in our method of procedure that differs from the usual is that we do not require that a record be perfect before accepting it. If the work is finished, the record is checked at the close of the period and graded for what it is worth. The student's attention is called to the errors. If there is time they are corrected.

If the student, because of lack of preparation or because of wasting his time, must finish his computation outside, the record is presented at the beginning of the next laboratory period. It is marked late and little or no credit is given. With this system of having all of the credited work done in the laboratory, faking of results and work is reduced to a minimum. Study-room teachers have reported with alarm that certain students were copying from other's note books. They are surprised when we tell them that we are not concerned, that it is a good sign, that the student is doing a little extra work for which he knows he will get no credit.

In our other science courses we confiscate the note books at the close of the semester to keep them out of circulation. We decided in physics that it was not worth the time and trouble. We do not care how a student gets his outside or previous preparation. If he can come to the laboratory and work his experiment correctly and knows how to compute his results and draw his conclusions, we feel quite contented. We are on the constant lookout to see that no written aids are brought into the laboratory and I believe, under the conditions, it would be rather difficult not to be discovered in the attempt.

For the brighter, faster-working students, who finish the experiment sometime before the close of the period, the manual provides an optional part. This is an extra task related in some way to the principle involved in the experiment. Whenever possible it is made more difficult than the problem of the experiment. If the student finishes the optional part in a satisfactory manner, credit is given in the column marked "optional" on the index page. Students like to try the optional part and many of them do the work outside. When the experiment or optional part is finished out of the laboratory the stamp is turned upside down. We also have three science magazines on a shelf in

the laboratory for the students who finish their work before the close of the period.

The monthly grades for the laboratory work are easily and quickly obtained by consulting the index page. Each experiment was graded when the instructor was best prepared to grade it. The final marks are consequently somewhat mechanically obtained and not dependent upon the mental and physical attitude of the instructor at the end of the month.

Five of the ten marks determining the monthly grade are obtained from the laboratory work. Two or three from the classroom discussions and three or two from tests. We still believe that factual knowledge should be some part of the benefits obtained from a course of study. To test the student for this phase of his work we use the completion test. With our laboratory system of previous preparation and individual work, each day's task is, we believe, the best test of the student's skill, achievement, or real knowledge of the principles and their applications.

We have classes in Physics I and Physics II following each other during the day. It is consequently necessary that the tables be cleared of apparatus at the close of each period. The students are required to get their own apparatus and replace it at the close of the period in the exact position in which they found it.

We have made a large number of drawers and trays. The duplicate pieces of apparatus are stored in the same drawer. We have two large cases in the laboratory for apparatus that can not be placed in drawers. If necessary it is possible for the instructor to lead his class into the laboratory and by pulling out a few drawers or by opening a case door, start the laboratory work without loss of time.

Until last year we have never been troubled with loss or theft of apparatus. Try as we would we could not catch the thief. The second semester we obtained from the book store and a paper company a great supply of boxes of different sizes. Apparatus that was small and attractive, or that might be taken away, was placed in individual boxes and numbered. The students have numbers and they were required to use the box with their number. These boxes were checked by the instructors and by students appointed for the task at different times. If a student did not report missing apparatus at the beginning of the period, he was held responsible. This worked

one hundred per cent for as soon as we neglected to put it in individual boxes apparatus would again disappear.

The laboratory system that I have described assumes a laboratory so equipped that in a large majority of the experiments the students can work individually and on the same experiment. Many have erroneously thought that the expense makes such a system prohibitive. But that is not true at least for those schools attended by the large majority of our physics students. At North Division we have gradually added to our equipment until now we have twenty-eight duplicate sets for a large majority of the experiments and yet our yearly budget has not been larger than that of other high schools of the city where twenty-eight to thirty-two experiments are performed during the entire year. Such an equipment can be obtained for about $3000.00 provided you are willing to use simple apparatus and in some cases home made.

Experiments in electricity are usually considered most expensive. Nearly all of our experiments in electrical measurements are performed individually. This does not require a large and extravagant expenditure because of unusual directions and arrangement of apparatus in each experiment. The directions given in many manuals require from two to five meters in the one experiment. This is not at all necessary. One volt-ammeter of ten range will serve all purposes. It can be connected in some part of the circuit and the desired magnitude determined. Then disconnected, the main circuit restored, and the meter reconnected at some other place or manner for the determination of the next magnitude desired. It is not necessary that all magnitudes be read simultaneously.

We use for our main circuit, two dry batteries, a key and a resistance box containing a one and a three ohm resistance and get perfect results. Our apparatus supply house placed an extra binding post on the end of the resistance box between the two rows of resistances so that the same box may serve as two boxes for the study of series and parallel circuits.

This main circuit together with the volt-ammeter cost about thirty dollars and with it we perform the following experiments: proof of Ohm's Law; voltmeter-ammeter method of measuring resistance; specific resistance of German-silver; series and parallel circuits; amperages of a divided circuit; resistance of a divided circuit; fall of potential proportional to resistance; terminal voltage; internal resistance of a cell; and battery

connections. Eleven experiments at a cost of thirty dollars and the same apparatus used in many other electrical experiments.

In light we use an optical bench for five experiments. The bench is obtained by using the 100 centimeter support rod, one end supported by a regular bench support and the other end by a 6×6 inch board with a three-quarter inch hole at the proper height. Holders for lenses, mirrors, objects and screens are held to the bench by means of the 2-V clamps of the desk equipment. All holders are home made so that the only additional expense for the five experiments is the cost of the lenses and the mirrors.

To make the holders, strips of wood $\frac{3}{4} \times 1\frac{3}{4}$ inches for the bottom and $\frac{3}{4} \times \frac{3}{4}$ inches for the sides are used. A narrow shallow groove is cut in the center of one edge. These are then cut to proper length so that when nailed together in a U form, the lens or object desired will slip into the grooves. For the screen a piece of white cardboard is placed in the groove of a holder. A large spike with the head removed is driven into the bottom piece. The spike is held in the 2-V clamp and serves as a means of holding the lens or mirror at any desired position or height. A large number of these holders can be made in a short time and at little expense.

We are particularly pleased with our home made object. It consists of a cubical box about three and one-half inches in each dimension, mounted on a rod so that it can be supported on the bench. In one side is bored a hole of the proper size to receive an electric light receptacle. At the opposite side of the box the top and bottom extend a short distance beyond the sides and contain grooves of such size and distance apart that a lantern slide may be placed therein forming that side of the box. A fifteen watt light bulb placed in the receptacle illuminates the slide and it becomes a fine object on which to focus.

This object has its advantages over the usual flame object. It does not illuminate the laboratory and interfere with the results of other workers. Students are inclined to think of any patch of light as an image. When focusing on printed matter a sharper adjustment is obtained. The slide may be replaced with a cardboard containing a narrow opening when a line of light is desired for obtaining a spectrum. It is also of use for the study of colors by placing different colored glasses in the grooves.

I have used these two illustrations of simplifying apparatus for electricity and light in an attempt to show that the matter of expense is not an argument against more extensive laboratory work. Simple home made apparatus can especially be used in mechanics. When the laboratory becomes well equipped, many experiments can be added to the list without additional apparatus. In the past year I have added five to my list in heat with out practically any extra expense. Simple apparatus has its advantages in its teaching possibilities. If the apparatus is complicated the student loses sight of the real purpose of the experiment. Simple apparatus is very essential for the success of the shorter period.

Whatever your method, your results or your success will depend mainly on two things: The amount of interest the students develop for the subject and the amount of real work they are willing to give to the subject. Modern youth are not as dumb as we sometime give them credit for being. It is a comparative few that can not accomplish a simple task, if they are willing to make an honest effort, and there is no principle in elementary physics that can not be presented in a simple way.

We feel that our laboratory problem method of teaching physics has developed these two desired attainments, interest and effort. Students, like children and most adults, like to do things for themselves. In spite of the definite requirements they are interested greatly in the laboratory work. The laboratory procedure with its definite daily problem, its compulsory preparation, its individual work, its daily report and check has been, judging from the results, very effectual in producing a conscientious effort.

Although the intended purpose of this number on your program was to explain a method by which successful laboratory work could be accomplished in one period of forty-five or fifty minutes, I hope you will pardon me for going a step farther and suggesting that the whole subject might be presented as a laboratory course with only single periods.

I have attempted again to advocate that the laboratory be made the nucleus of the entire course, introducing all principles, laws or subject matter, whenever possible, by student laboratory work. I am again advocating that the best way to learn is by doing; that the students and not the instructor should get the experience and the knowledge acquired by doing the work.

A FEW OBSERVATIONS IN CHEMICAL SPELLING

By L. E. Blackman
Kansas State Teachers College of Emporia, Emporia, Kansas

It has been remarked that one of our subjects which is fast becoming one of the "lost arts" is spelling. This statement is probably a bit extreme but it seems to be true that we are more lax in our spelling than we should be for our own good. The author has known of one case where the misspelling of a common word cost the applicant a good position in a large college. This is probably the extreme penalty that might be suffered from such practice. In this particular instance it meant, or at least suggested to the employer, carelessness on the part of the applicant, a trait which he evidently did not desire in his teachers. It would seem plausible that more use should be made of the dictionary. However, one does not go to this trouble if he thinks he is right in the first place. There is then nothing to instigate such a search and confirmation. Many times in a chemical laboratory, a student has mistaken an "a" for an "i" and has failed to get the correct results. One incident of this kind which is recalled just now involved the substitution of sodium nitrate for sodium nitrite in the preparation of nitrogen. The student was perplexed and wondered where the mistake could have occurred, and as usual, he blamed it on the book rather than on anything he himself might have done.

Chemistry is an exact science. One can not afford to disregard and sacrifice care and attention for details if he desires the greatest benefit from science. There is a difference of only one atom of chlorine between mercuric chloride and mercurous chloride; yet, what a difference this one atom makes when we have occasion to take these substances internally. On the other hand, you hear the joking inquiry, "What's a molecule among friends, anyway?" But the fact still remains—friendship does not alter the properties of the molecule.

It is reasonable to think that by the time a student reaches college, he should be able to correctly spell the more common words. Yet the author's observations over a period of fifteen years have pointed to the contrary for a great many students. No doubt other teachers of science have experienced similar observations. It has been suggested that since the passing of the old "spelling-bee," our good spellers have become less nu-

merous. Yet many schools still find much profit is gained from these contests. It would seem that this problem could be materially helped by the work of chemistry or science clubs in high schools and colleges. Chemical or scientific spelling contests could be held once a semester to encourage and promote correct spelling of common technical terms.

A new system is being used with considerable success in the Teachers College at Creeley, Colorado. Here, as one requirement, a student must correctly spell all words in every course taken before passing that course. This is accomplished through cooperation with the English department. All papers, note books, reports, etc., required in each course must pass the inspection of the English department. This appears to be a very logical step toward the development of better spellers in the schools. Under the present plan of most schools, the English teacher has the student under supervision one hour a day; then the student does most anything he desires the rest of the day in undoing the work of that hour. Some such modern plan as the above can certainly do no more harm than our present scheme and undoubtedly will lead to a more practical education.

The author has taught in high school, college and university. During a period of fifteen years he has collected a few words which have been found to be most frequently misspelled by the various types of students. These words are listed below in the hope that other teachers may try to correct their usage by students with whom they come in contact. The most frequent offenders are placed at the top of the list and their usual incorrect spellings listed opposite the word. No doubt the list can be greatly enlarged and improved upon through the observations of other teachers along this line. The author would be pleased to hear from any other co-workers in science interested in this phase of development and to learn their reactions in the matter.

Word	*Incorrect spelling*	*Word*	*Incorrect spelling*
soluble	soluable	carat	kerat
dissolve	desolve, disolve	burette	burrette
precipitate	percipitate	reversible	reversable
equation	equasion	occurrence	occurence
gases	gasses	chemistry	chemestry
symbol	symble, cimbal, simbol	quantitative	quanitative
		quantity	quanity
liquefy	liquify	occlusion	oclusion
vacuum	vaccuum	paraffin	parafine
balloon	baloon	inert	innert

Word	*Incorrect spelling*	*Word*	*Incorrect spelling*
phosphorus	phosphorous	hydrofluoric	hydroflouric
fluorine	flourine	hematite	hemitite
definite	definate	metallurgy	mettalurgy
viscous	viscus	alkali	alkaly, alkili
sulfur	sulfer	liquefaction	liquifaction
atom	attom	aniline	analine
qualitative	qualatative	Priestley	Priestly
arsenate	arsinate	Avogadro	Avagadro
fuel	fule	invisible	invisable
omit	omitt	methyl	methol
ethyl	ethel	octave	octive
valence	valance	annealing	anealing
particle	partical	flammable	flammible
desiccator	dessicator	usually	usualy
laboratory	labratory	antiseptic	anticeptic
radical	radicle	diffusion	diffussion
efflorescence	efflouresence	amorphous	ammorphis
effervescence	efforvesence	Henry	Henery
alkaline	alkiline, alclyne	catalytic	catilitic
thermometer	thurmometer	bicarbonate	bycarbonate
prepared	prepaired	cuprous	cupurous
deliquescence	delequesence	verdigris	verdigree
fluoride	floride	divisible	devisable
until	untill	fermentation	fermantation
coke	coak	crystallize	cristalise
iron	iorn	electrolysis	electrolasis
nascent	nacent	conservation	concervation
ferrous	ferous	amalgam	amalgum

EXCITEMENT'S EFFECT ON BLOOD REPORTED

The specific gravity of blood is greater during excitement than when one is calm, and the spleen, a red blood cell factory in the body, is partially responsible, experiments by Drs. L. B. Nice and H. L. Katz of Ohio State University show. Specific gravity gives the weight of a unit volume of blood or other fluid compared with the weight of the same unit of water.

The two scientists have been studying the effects of excitement on rabbits and cats. In normal animals the increase in specific gravity of the blood after they had been excited was quite marked, but in rabbits whose spleens had been removed this increase was much smaller.

The experimenters ascribe their results to the removal of water by body tissues from the blood, the addition to the blood of the waste products of the animal's speeded-up life processes, and most important, the actual contraction of the spleen to force red blood cells into the blood stream.

Since the red blood corpuscles carry oxygen from the lungs to points where it is needed, this makes more oxygen available to the muscles, nerves, and glands so that it is possible to act more quickly and more forcibly in response to whatever it is that is producing the fear, rage, or other emotion.

Studies showing the same effect of excitement on the blood of pigeons were reported by Dr. Nice and Dr. D. Fishman at the meeting in Washington of the American Physiological Society.

GRAPHICS IN EDUCATION

By Norman Arnold
Purdue University, Lafayette, Indiana

It is a fairly well recognized fact that "symbolism" plays a very important role in modern life. One can readily agree that the mathematician, chemist, doctor, and engineer employ symbols not recognized by the uninitiated, but the average person reads the comic strips in the daily paper without being consciously aware that the comic artists have developed a special symbolism of their own for conveying ideas. The stars for a blow on the head, the reduction in stature, and the shading of the face to represent extreme embarrassment are a few of the more common symbols of the craft. The written language has changed so greatly since the pictorial hieroglyphics of the early Egyptians that in shorthand, in the telegraph codes, and other codes, we even have symbols for the symbols. And it is a rare word that, when written, has any resemblance to the thing it represents. The spoken language is slightly more vivid, and still contains some words which are suggestive by their sound, such as hiss, plop, buzz, hoot, snore, zig zag, crisscross, and the like.

As a result of the motion picture, rotogravure newspaper, and many other forces, there is a marked tendency to return to simpler, more direct, and more easily comprehended styles of thought communication. Highway markers with curves, crosses, etc. in place of words are one common example of this.

The technical developments of this century have led to widespread use of graphical methods in industry. The blacksmith who made the sparks fly under the spreading chestnut tree had no need of a blueprint to show him how to shoe a horse or fix a buggy, but the automobile mechanic who has succeeded him is practically forced to obtain from drawings some of the information about the complex mechanisms, especially when a new model first appears. The popularization of radio caused millions of people to learn the intricacies of connection diagrams, and many youths and adults will continue to be attracted to radio, and will need to be able to read wiring diagrams. If low-cost houses become an actuality, another large group of persons interested in constructing their own homes will learn about house plans.

Economists and statisticians, who have come to the fore in

the popular mind during the last few years, are adopting graphical methods more extensively in their work because such methods lend themselves readily to the quick presentation of quantitative information, and even to the illustration of principles. Historically, maps are the earliest known form of symbolic graphic representation. Their importance has been greatly increased by the automobile, radio, airplane, and all the other factors tending to broaden our sphere of geographical interests. Elementary maps of a familiar neighborhood can be understood and made by children not yet able to read, and they might be introduced in the schools much earlier than they are with beneficial results.

It is quite natural that important changes in ways of living and doing should be felt in the school curricula after their manifestation outside of the school. As most readers are aware, motion pictures have been employed to some extent for educational purposes, and there is a very definite place for them in the scheme of things, but the use of motion pictures is more spectacular than some other similar methods which may be employed to make school subjects vivid and vital. Better illustrated textbooks are of tremendous value in this respect, and greater use of diagrammatic illustrations by teachers can be extremely helpful. Progress is being made along these lines, but the inertia opposing changes that is inherent in a large and widely scattered group of teachers is enormous, and the movement should be accelerated in some way.

It is significant that some of the newer high school mathematics books contain a large number of problems requiring graphical answers instead of a single number or equation. A more thorough grasp of the principles naturally results from obtaining or presenting the solutions in graphical form.

It may be well to point out that there are three distinct phases to "graphics in education." (1) Because of the present and growing importance of graphics in our daily life, the public schools should help students to acquire some skill in reading and interpreting various types of graphical diagrams in order that they may be equipped to function more effectively as citizens in this technical age. (2) The ability to represent ideas in graphical form is a corollary to item one. An increasing percentage of persons will find need for this skill, but it is less necessary than the ability to read the graphical language, just as writing is less necessary than reading. (3) Associated with increased training

in graphic methods, there should be a further increase in their use by teachers and textbooks as a means of conveying ideas—resulting in even more efficient teaching. No one of these three steps can actually precede the other two, because they are so closely inter-related, but the initiative will have to come from parents or from teachers—preferably from teachers who can visualize the value of another teaching channel, more direct and more exact in expression, than words.

VITAMIN B MAY PLAY PART IN BODY'S FAT PRODUCTION

A new role for vitamin B, helping the body gain weight by building up fat, is suggested by experiments reported by Drs. Dorothy V. Whipple and Charles F. Church of the University of Pennsylvania School of Medicine at the meeting of the American Society of Biological Chemists.

Animals given diets that contained no fat but plenty of vitamin B were able to gain more weight than their mates on the same fat-free diet but without the vitamin. Comparing the average body composition of the animals, the Philadelphia investigators found that fat accounted for half the gain in weight made by the animals on the vitamin diet. Water accounted for the other half of the weight gain.

The figures, they reported, suggest the possibility that vitamin B plays a role in the building up of fat in the animal body.

Vitamin B is found in moderate amounts in most natural foods, but its chief sources are wholemeal cereals, yeast, peas, beans, egg yolk, nuts, liver, kidney and heart. Lack of this vitamin causes beri-beri, a disease mostly found in the Orient, but which can occur anywhere if this vital food factor is omitted from the diet.

Consequently, fat persons cannot hope to lose weight by omitting vitamin B from their diet, even if the investigations reported today are confirmed and the vitamin is found actually to be important in weight-building. But thin persons wanting to gain weight may in the future be advised to add liberal amounts of the vitamin to their diet.

ORIENTAL CHESTNUT TREES PLANTED IN NATIONAL FOREST

Extensive experimental planting of chestnut trees from Asia are to be made in the George Washington National Forest in Virginia's Blue Ridge this spring. The test is to determine whether the trees can take the place of the native chestnuts, practically wiped out during the past three decades by the fungus-caused chestnut blight.

This fungus came to America from the Orient, where chestnut trees are resistant to it. Many varieties of Oriental chestnuts have been brought to this country by plant explorers of the Department of Agriculture, and their seedlings are now ready for planting.

The destruction of the chestnuts was a major blow to American forest industries, for the chestnut is a tree of many uses. It yields rough timber, wood for furniture making, bark for tanning, nuts for human food, and is also one of the most valuable trees for the support of wildlife in the forest.

SCIENCE LIBRARY FOR JUNIOR AND SENIOR HIGH SCHOOLS

By Ellis C. Persing
Western Reserve University, Cleveland, Ohio

Teachers will find the books suggested in this list helpful in supplementing the regular textbook and as general references. This is not a complete list but one which contains those books which have appeared since the publication of the second list in School Science and Mathematics, December 1932. The writer has found that elementary science teachers are keenly interested in knowing about the books which are helpful in teaching science. The present titles are for the most part books which have appeared since publication of the previous lists.* New books which help us to keep up with science are constantly coming from the publishers. For our school libraries we must therefore find these books which are adapted to the teachers' and pupils' needs and add them to our shelves.

STUDENT'S REFERENCES

Agriculture

Schmidt, Chas. C. Nature Study, Agriculture, D. C. Heath Co., 1933, $1.80. Subject matter for teachers and pupils of the upper grades.

Animals

Leister, Claude W. Present Day Mammals, Zoological Society, 1931, $1.00. A manual for mammals with brief notes and illustrations.

Needham, James Geo. The Animal World, The University Series, The University Society, 1931, 65¢. An interesting subject matter for teacher's background and discussion groups.

Chapman, Frank M. Autobiography of a Bird Lover, D. Appleton-Century Co., 1933, $3.75. A fascinating autobiography.

Biology

Barrows, Henry R. College Biology, Richard R. Smith Inc., 1931, $3.50. A textbook in college biology.

Jaeger, Edmund C. The California Deserts, Stanford University Press, 1933, $2.00. Information about the Colorado Mohave Deserts for the general reader and traveler. Helpful and interesting illustrations.

Daglish, Eric Fitch. How to See Birds, Wm. Morrow & Co., 1932, $1.50. Practical information on how to make birds your friends.

Saunders, Aretas A. A Guide to Bird Songs, D. Appleton-Century Co., 1935, $2.50. A unique handbook for easy study and identification based upon a simple description and diagram key easily understandable by all.

Earth

Fenton, Carroll Lane. World of Fossils, D. Appleton-Century Co., 1933, $2.00. Secrets of the Fossil World written for the Layman.

* This journal, Vol. xxxii. No. 1; Vol. xxxii. No. 9.

Papp, Desiderius. Creation's Doom, D. Appleton-Century Co., 1934, $3.00. Describes how the world will end, and what will be man's ultimate fate.

Reeds, Chester A. The Earth, The University Series, The University Society, 1931, 65¢. Subject matter as background for teachers and discussion groups.

Hawks, Ellison. The Book of Electrical Wonders, Dial Press, 1929, $3.00. How electricity is produced, gigantic power stations, hydro-electric schemes, methods of transmitting electricity, electrical lighting, uses of electricity.

Lehmann, Herbert B. Shop Projects in Electricity, American Book Co., 1934, 96¢. Directions for making numerous electric devices.

Evolution

Crampton, Henry Edward. The Coming and Evolution of Life, The University Series, The University Society, 1931, 65¢. Subject matter for teachers' background and discussion groups.

General

Fletcher, Basil A. Youth Looks at the World, Frederick A. Stokes Co., 1933, $2.75. Colorful tale of travels, wayside conversation with men and women of all nations.

Published by the American School and University. The American School and University Year Book, 1935. Current thought and practices on many phases by the educational plant with manufacturer's current catalogue of materials, equipment and supplies.

Naturalist Directory. Published by Samuel E. Cassino, 1934, $4.00. Contains names, addresses and special subjects of study of professional and amateur naturalists of North and South America.

Geography

Peattie, Roderick. New College Geography, Ginn and Company, 1932, $3.00. A text for college or university grades.

Whitbeck, R. H. & Thomas, Olive J. The Geographic Factor, The Century Co., 1932. Background and subject matter for teachers and students of geography.

Lull, Richard Swann. Fossils, The University Series, The University Society, 1931, 65¢. The story of what fossils tell us of plants and animals of the past.

Health

Turner, E. C. & Morgan, Nell J. & Collins, G. B. Home Nursing and Child Care, D. C. Heath Co., 1930, $1.20. Classroom guide for upper Junior High School and lower Senior High School levels.

Emerson, Haven M. D. Alcohol, Its Effects on Man, D. Appleton-Century Co., 1934, $1.00. Answers all the usual questions on alcohol and its effect upon the different systems of the human body.

Heavenly Bodies

Maxim, Hiram Percy. Life's Place in the Cosmos, D. Appleton-Century Co., 1933, $2.50. The history and structure of the universe, the development of human life upon the earth.

Menzel, Donald H. Stars and Planets, The University Series, The University Society, 1931, 65¢. Exploring the universe—astronomy.

Moseley, E. L. Other Worlds, D. Appleton and Co., 1933, $2.00. Facts for the busy reader about some of the heavenly bodies.

Sheldon, H. Hornton. Space, Time and Relativity, The University Series, The University Society, 1932, 65¢. Historical background on the special theory, Einstein's fifth paper.

Indians

Smith, White Mountain, Mrs. Indian Tribes of the Southwest, Stanford University Press, 1933, $1.50. About the Southwest and its people.

Man's Development

Bean, Robert Bennett. The Races of Man, The University Series, The University Society, 1932, 65¢. An account of the differentiation and dispersal for the layman. Attractive illustrations.

MacCurdy, George Grant. The Coming of Man, The University Series, The University Society, 1932, 65¢. An account of pre-man and prehistoric man for the layman. Attractive illustrations.

Collins, Herbert E. Warpath and Cattle Trail, Wm. Morrow and Co., 1933, $1.50. An interesting story of the old west, especially for boys. A foreword by Dan Beard.

Microscopic Life

Calkins, Gary N. The Smallest Living Things, The University Series, The University Society, 1932, 65¢. Life as revealed by the microscope. Excellent diagrams and photomicrographs.

Physics

Bazzoni, Chas. B. Energy and Matter, The University Series, The University Society, 1932, 65¢. The building blocks of the Universe. Diagrams and photographs.

Hodgman, Chas. D. Handbook of Chemistry and Physics, Chemical Rubber Publishing Co., 1934, Price $6.00. Special price to students $3.00. A handbook for teachers of the physical sciences.

Hodgman, Chas. D. Mathematical Tables, Chemical Rubber Publishing Co., 1933, $1.50. Tables from the handbook of chemistry and physics.

Langdon-Davis, John. Inside the Atom, Harper and Bros., 1933, $2.00. A strange story of whirling atoms and invisible waves.

Mott-Smith, Morton. Heat and Its Workings, D. Appleton and Co., 1933, $2.00. From Watt's steam engine to modern refrigeration. The whole story of modern application of heat.

Mott-Smith, Morton. The Story of Energy, D. Appleton-Century Co. 1934, $2.00. Story of how man has captured and harnessed physical energy.

Wilson, H. A. Mysteries of the Atom, D. Van Nostrand Co., 1934, $2.50.

Plants

Daglish, Eric Fitch. How to See Plants, Wm. Morrow & Co., 1932, $1.50. Includes plants common to American gardens, fields, and woods.

Gager, C. Stuart. The Plant World, The University Series, The University Society, 1931, 65¢. Treats of the plant life of our earth.

James, W. O. An Introduction Plant Physiology, Oxford at the Clarendon Press, 1933, $2.50. A balanced account of the more elementary aspects of plant physiology.

Robbins, Wilfred W. & Pearson, Helen M. Sex in the Plant World, D. Appleton-Century Co., 1933, $2.00. A treatment of sex in the plant world for the layman.

Radio

American Radio Relay League. *The Radio Amateur's License Manual*, American Radio Relay League, 1934, 25¢. *The Radio Amateur's Handbook*, 1934, $1.00. *Hints and Kinks*, 1933, 50¢. *How to Become a Radio Amateur*, 1933, 50¢. Practical handbooks for the radio amateur.

Darrow, B. H. Radio, the Assistant Teacher, R. G. Adams and Co., 1932. What has been done in radio and the future of radio for the schools.

Ramsey, R. R. Experimental Radio, R. R. Ramsey, 1929, $2.75. A series of experiments with directions for performing them.

Ramsey, R. R. Fundamentals of Radio, Ramsey Publishing Co., 1929, $2.75. Basic theory of radio as it is found in modern practice.

Travel

Lindsay, Martin. The Epic of Captain Scott, G. P. Putnam Sons, 1934, $1.50. Description of Captain Scott's record march to the south pole, and the tragedy of the return.

TEXTBOOKS

Biology

Atwood, Wm. H. & Heiss, Elwood D. Educational Biology, P. Blakiston's Sons, 1933.

Baker, A. O. & Mills, Lewis H. Dynamic Biology, Rand McNally & Co., 1933, $1.72.

Curtis, Francis D. & Caldwell, O. W. & Sherman, N. H. Biology for Today, Ginn and Company, 1934, $1.76.

Fitzpatrick, F. L. & Horton, Ralph E. Biology, Houghton-Mifflin, 1935, $1.76.

Hunter, George W. Problems in Biology, American Book Co., 1931, $1.76.

Mank, Helen Gardner. The Living World, Benj. H. Sandborn Co., 1933, $1.68.

Moon, Truman J. & Mann, Paul B. Biology for Beginners, Henry Holt Co., 1933, $1.72.

Pieper, Chas. J. & Beauchamp, Wilbur L. & Frank, O. Everyday Problems in Biology, Scott, Foresman & Co., 1932, $1.60.

Smallwood, W. M. & Reveley, Ida L., Bailey, G. A. New Biology, Allyn and Bacon, 1934, $1.80.

Physics

Miller, Fred R. Progressive Problems in Physics, D.C. Heath Co., 1933, $1.32.

Chemistry

Bruce, George Howard. High School Chemistry, World Book Co., 1933, $1.68.

Teaching of Science

Hunter, George W. Science Teaching, American Book Company, 1934.

Cole, William E. The Teaching of Biology, D. Appleton-Century Co., 1934, $2.00.

General Science

Harrah, Jean & Herman & Powers. Introductory course in Science Bk.I, Man and the Nature of his Physical Universe, Ginn and Co., 1934, $2.20.

Harrah, Jean & Herman & Powers. Introductory Course in Science Bk. II, Man and the Nature of his Biological World, Ginn and Co., 1934, $2.40.

Hunter, George W. & Whitman, Walter G. Problems in General Science, American Book Co., 1934, $1.72.

Lake, Chas. H. & Harley, H. P. & Welton, L. E. Exploring the World of Science, Silver, Burdett & Co., 1934, $1.76.

Powers, S. R. & Neuner, E. F. & Bruner, H. B. A Survey of Science, The Changing World, Ginn and Co., 1934, $1.40.

Powers, S. R. & Neuner, E. F. & Bruner, H. B. A Survey of Science, The World Around Us. Ginn & Co., 1934, $1.20.

Skilling, W. T. Tours Through The World of Sciences, McGraw-Hill, 1934, $1.70.

Mathematics

Brueckner, L. J. & Farnam, L. M. & Woosley, Edith. Mathematics for Junior High Schools, Bk. III, John C. Winston Co., 1931, $1.28.

Sykes, Comstock & Austin. Plane Geometry, Rand McNally & Co., 1932, $1.28.

Sykes, Comstock & Austin. Solid Geometry, Rand McNally & Co., 1933, $1.12.

WORK BOOKS

Biology

Bailey and Greene. New Laboratory Manual, Allyn and Bacon, 1928.

Baker-Mills. Activities for Dynamic Biology, Rand McNally & Co., 1933, 80¢.

Beauchamp, Wilbur L. A Study-Book in Biology, Scott, Foresman & Co., 1934, 80¢.

Blaisdell, J. Glenn. Exercise Book in High School Biology, World Book Co., 1933, 72¢.

Downing & McAtee. Problem Solving in Biology, Lyons and Carnahan, 1934, 80¢.

Kinsey. Workbook in Biology, J. B. Lippincott Co., 1934.

General Science

Lake, C. H.; Welton, L. E.; Adell, J. C. A General Science Workbook, Silver, Burdett & Co., 1932, $1.00.

Heiss. Science Problems of Modern Life, Bks. I & II, Webster Publishing Co., 1933, 56¢.

Pulvermacher and Vosburgh. General Science Laboratory Sheets, Globe Book Co., 1932, 73¢.

Weed and Rexford. A Laboratory Manual to Accompany Useful Science, Bks. I & II. John C. Winston Co., 1932, Bk. I, 36¢; Bk. II, 56¢.

Geography

Branom, Mendel E. Geography Problem Projects; South America, Africa, Asia, Europe. A. J. Nystrom & Co., 35¢.

McConnell, W. R. Study Guide Lessons in Geography; Western Hemisphere, 30¢; Asia, Africa, Australia, and New Zealand, 18¢; U. S. and Neighboring Lands, 18¢; Eastern Hemisphere, 27¢. Webster Publishing Co.

Mathematics

Strader, W. W. and Rhoods, L. D. Objective Exercise in Units of Plane Geometry, J. C. Winston Co., 1932.

Health

Gregg, F. M. & Rowell, H. G. Health Studies, Home & Community, World Book Co., 1932, 76¢.

Gregg, F. M. & Rowell, H. G. Health Studies, Personal Health; World Book Co., 1932, 84¢.

Chemistry

Powers, Samuel Ralph & Johnson, Ruth Maude. Work Book in Chemistry, Allyn and Bacon, 1931.

SCIENCE LIBRARY FOR ELEMENTARY SCHOOLS

STUDENTS' REFERENCES

Agriculture

McIntosh and Orr. First Problems in Agriculture, American Book Co., 1934, $1.00. Textbook for elementary school.

Animals

Brown. D. L. Butterfield, Marguerite. Bozo, the Woodchuck, American Book Co., 1933, 44¢. A true story about a woodchuck.

Cormack, Maribelle, Alexander, Wm. P. The Museum Comes to Life, American Book Co., 1931, 76¢. Subject matter dealing with specimens ordinarily found in museums.

Harte, H. S. The Lion, Orthovis Co., 1934. An interesting story with splendid illustrations. Pictures to be used with the orthoscope.

Harte, H. S. The Deer, Orthovis Co., 1934. An interesting story with splendid illustrations. Pictures to be used with the orthoscope.

Harte, H. S. Wild Sheep and Goats, Orthovis Co., 1934. An interesting story with splendid illustrations. Pictures to be used with the orthoscope.

Harte, H. S. The Bear, Orthovis Co., 1934. An interesting story with splendid illustrations. Pictures to be used with the orthoscope.

The Animal Kingdom. Orthovis Co., 1933, $2.00. A series of animal pictures with brief subject matter notes for each. When viewed with the orthoscope, interesting details are brought out.

Knecht, Klara E. Animal Book, Saalfield Pub. Co. Pictures of animals from paintings. Stories for the primary grades.

Knecht, Klara E. The Circus, Saalfield Pub. Co. Stories of the circus, well illustrated.

Thorne, Diana. Baby Animals, Saalfield Pub. Co. Animal pictures and stories for younger children.

Biography

Hallock, Grace T., Turner, C. E. Health Heroes, E. L. Trudeau, D. C. Heath Co., 1928, $1.12. The story of an interesting man and his contribution toward the prevention of tuberculosis.

Hallock, Grace T., Turner, C. E. Health Heroes, Ed. Jenner, D. C. Heath Co., 1928, $1.12. The story of an interesting man and his contribution for the control of smallpox.

Hallock, Grace T., Turner, C. E. Health Heroes, Louis Pasteur, D. C. Heath, 1928, $1.12. The life story of a great scientist.

Birds

Kenly, Edmund C. Wild Wings, D. Appleton and Co., 1933, $2.50. Designed to interest younger readers in bird-lore.

King, Julius. Birds, Bk. I, Harter Publishing Co., 1934, 10¢. Good pictures and interesting subject matter.

King, Julius. Birds, Bk. II, Harter Publishing Co., 1934, 10¢. Good pictures and interesting subject matter.

King, Julius. Birds, Bk. III, Harter Publishing Co., 1934, 10¢. Good pictures and interesting subject matter.

Peat, F. B. Birds, Saalfield Pub. Co. A series of bird pictures with brief notes for younger children.

Bird Kingdom. Orthovis Co., 1934, $2.00. An interesting collection of bird pictures with brief notes designed for use with the orthoscope.

Communication

Webster, Hanson Hart. The World's Messengers, Houghton-Mifflin, 1934, $1.04. The history and the development of communication. Attractive and helpful illustrations.

Earth and the Sky

Shackelford, Frederick H. Earth and Sky Trails, Harr Wagner Pub. Co., 1932, 80¢. Treatment of the earth and the heavenly bodies.

Washburne, Carleton and Heluiz. The Story of Earth and Sky, D. Appleton-Century Co., 1933, $3.50. Helps to answer many of the children's questions about the earth and the sky.

Farm

Beaty, J. Y. The Farmer at his Work, Saalfield Pub. Co., How the farmer works, good pictures on the activities of the farm.

Beaty, J. Y. On our Farm, Saalfield Pub. Co. An interesting story of life on the farm with interesting pictures.

Geography

French, Ann Schilt. Stories of Hawaii, Houghton-Mifflin Co., 1933, $1.50. Deals with the history from the earliest records and discusses two leading industries, sugar cane and pineapple.

Weinber, Louis, Scott, Z. E., Hoston, Evelyn. The World We Live in, D. C. Heath Co., 1932, 92¢. An introduction to geography for intermediate grades.

Health

Turner, E. C., Pinckney, Jennie M. In Training for Health, D. C. Heath Co., 1929, 60¢. A series through the elementary grades and junior high schools.

Turner, E. C., Hallock, Grace T. The Voyage of Growing Up, D. C. Heath Co., 1928, 60¢. A series through the elementary grades and junior high schools.

Turner, E. C., Collins, Georgie B. Community Health, D. C. Heath Co., 1928, 84¢. A series through the elementary grades and junior high schools.

Turner, E. C. Physiology and Health, D. C. Heath Co., 1929, 96¢. A series through the elementary grades and junior high schools.

Turner, E. C. Health, D. C. Heath Co., 1930, 72¢. A series through the elementary and junior high schools.

Turner, E. C., Collins, Georgie B. Cleanliness and Health, D. C. Heath Co., 1932, 80¢. A series through the elementary and junior high schools.

Insects

Raric, Frances H. The Ant-Queen's Home, D. C. Heath, 1932, 80¢. Stories about insects.
Rendl, George. The Way of A Bee, Henry Holt and Co., 1933, $2.00. A translation from the German.

Science Readers and Texts

Craig, Gerald S., Johnson, Goldie M. Pathways in Science, Our Earth and its story, Ginn and Co., 1932, 76¢.
Nichols, M. Louise. Science for Boys and Girls, J. B. Lippincott Co., 1934, $1.20.
Patch, Edith M., Howe, H. E. Hunting, Macmillan, 1934, 80¢.
Patch, Edith M., Howe, H. E. Outdoor Visits, Macmillan, 1934, 84¢.
Patch, Edith M., Howe, H. E. Surprises, Macmillan, 1934, 84¢.
Patch, Edith M., Howe, H. E. Through Four Seasons, Macmillan, 1934, 88¢.
Patch, Edith M., Howe, H. E. Science At Home, Macmillan, 1934, 92¢.
Reh, Frank. Heat and Health, American Book Co., 1932, 60¢.
Reh, Frank. Light Forces and Machines, American Book Co., 1932, 60¢.
Reh, Frank. Magnetism and Electricity, American Book Co., 1932, 60¢.
Reh, Frank. Water, Air and Sound, American Book Co., 1932, 60¢.
Teeter, W. R., Heising, Clara M. Early Journeys in Science, Bks. I, II, III, Lippincott, 1931.

Ships

Dukelow and Webster. The Ship Book, Houghton-Mifflin Co., 1931, $1.12. Ocean liners, cargo ships, oil tankers, tug boats, dredges, river steamers, sailing ships, lake steamers, boats for play, rules of the road at sea, safety at sea, first boats, early traders, famous ships.

Supplementary Readers

The Story of the World, a set of ten volumes.
Fontany, Elena. Other Worlds than This, Thomas S. Rockwell, 1930, $1.25.
Hayes, Elizabeth LeMay. What Makes up the World, Thomas S. Rockwell, $1.25.
Heal, Edith. How the World Began, Thomas S. Rockwell, 1930, $1.25.
Heal, Edith. How the World is Changing, Thomas S. Rockwell, 1930, $1.25.
Heile, Maryanna. The World's Moods, Thomas S. Rockwell, 1930, $1.25.
McGill, Janet. The Garden of the World, Thomas S. Rockwell, 1930, $1.25.
Pollak, Janet. The Physical World, Thomas S. Rockwell, 1931, $1.25.
Powers, Margaret. The World of Insects, Thomas S. Rockwell, 1931, $1.25.
Stephenson, Mary Bowen. The World of Animals, Thomas S. Rockwell, 1930, $1.25.
Stephenson, Mary Bowen. The World of Invisible Life, Thomas S. Rockwell, 1931, $1.25.

The Story of Man, a set of ten volumes.
Ambler, Mary B. Man and His Riches, Thomas S. Rockwell, 1931, $1.25.
Barnes, Franklin. Man and His Records, Thomas S. Rockwell, 1931, $1.25.
Davis, Dorothea H. How the World Supports Man, Thomas S. Rockwell, 1931, $1.25.

Fisher, Anthony R. This Man Made World, Thomas S. Rockwell, 1931, $1.25.
Fry, Margaret. Man and His Customs, Thomas S. Rockwell, $1.25.
George, Carrie L. How the World is Ruled, Thomas S. Rockwell, $1.25.
Hayes, Elizabeth L. The Tongues of Man, Thomas S. Rockwell, 1931, $1.25.
Kiner, Grace. How the World Grew Up, Thomas S. Rockwell, 1930, $1.25.
Nash, J. V. How the World Lives, Thomas S. Rockwell, 1931, $1.25.
Nash, J. V. Races of Men, Thomas S. Rockwell, $1.25.

Things to Make

Collins, A. Frederick. Making Things for Fun, D. Appleton-Century Co., 1934, $2.00. Directions for a variety of things one can make.
Hall, Neely. Handicraft for Handy Boys, Lothrop, Lee and Shepard Co., 1933, $2.50. Pictures and suggestions for work and play.

Transportation

Reed, Brian. Railway Engines of the World, Oxford University Press, 1934, 75¢. Interesting illustrations and information of engines of the world.
Webster, Hanson Hart. Travel by Air, Land and Sea, Houghton-Mifflin 1933, $1.08. Airplanes, dirigibles, railways, autombiles, vehicles of the high-ways, ships of the seas, development of transportation.

Trees

King, Julius. Talking Leaves, Harter Publishing Co., 1934. 10¢. The trees, the leaves and a map showing the distribution of the species with very brief notes.

TEACHERS' REFERENCES

ELEMENTARY SCHOOL

Bibliography

Vinal, Wm. G. Nature Education, Curriculum Laboratory, 75¢. A selected list of books for nature education.

Charts

Richards, L. W., and G. L. Jr. Geologic History at a Glance, Stanford University Press. A geological history in the region of the Grand Canyon at a glance.

Childcraft

Childcraft, a Book of Verse. W. F. Quarrie Co., First volume of series entitled Childcraft, adapted for parents' and teachers' use.

Courses of Study

Hadsall, Leo F. Suggestions to Teachers for the Science Program in Elementary Schools, California State Dept. of Education.
Suggested Courses of Study in Science for Elementary Schools. State of Calif. Dept. of Education, 1932.
Science in the Elementary School, Suggested units, grades 1–7. State Dept. of Education, Baltimore, Md., 1933.
Courses of Study in Science, Grades 1, 2, 3. Commonwealth of Pa., Dept. of Public Instruction, 1932.

Courses of Study in Science, Grades 4, 5, and 6. Commonwealth of Pa., Dept. of Public Instruction, 1932.

Education

Slavson, S. R., Speer, Robert K. Science in the New Education, Prentice-Hall, 1934, $2.50. A Historical survey of science education, nature of children's interests, determining children's interests, biological and physical science interests, social objections of science education, current practices in science education.

Fish

Coates, Christopher W. Tropical Fish as Pets, Liveright Pub. Co., 1933, $2.50. The care of tropical fishes for private aquarium.

Fruits

Gardner, Victor Ray, and Bradford, F. C., Hooker, H. D. Fundamentals of Fruit Production, McGraw-Hill Book Co., 1922, $4.50. Comprehensive treatment of the fundamentals of fruit production.

General Reference

Downing, Elliot R. An Introduction to the Teaching of Science, The University of Chicago Press, 1934, $2.00. The major goals and specific objectives; skill in scientific thinking; the science curriculum, organization of units, supervised study.

Furbay, John Harvey. Nature Chats, The Science Press, 1933, $1.75. Short essays arranged according to the seasons, autumn, winter, spring and summer.

Harrah, Jean & Herman & Powers. Introductory course in Science Bk. I, Man and the Nature of his Physical Universe, Ginn and Co., 1934, $2.20. Introductory course for colleges and universities.

Harrah, Jean & Herman & Powers. Introductory Course in Science Bk. II, Man and the Nature of his Biological World, Ginn and Company 1934, $2.40.

McCorkle, Paul & Laura J. College Physical Science, P. Blakistons' Sons, 1934, $2.00. An orientation course at college level.

Published by the Division of Publication. Carnegie Institution of Washington, News Service Bulletin. A series of news service bulletins suitable for school use.

Thomson, Sir J. Arthur. Outline of Natural History, G. P. Putnam's Sons, $5.00. Treatment of animals from mammals to the simplest forms.

Genetics

Dunn, L. C. Heredity and Variation, The University Series, The University Society, 1932, 65¢. Designed for orientation course and individual discussion group.

Sinnott, Edmund W. & Dunn, L. C. Principles of Genetics, McGraw-Hill, 1932, $3.50. A textbook for courses in genetics.

Geology

Schuchert, Charles & Dunbar, Carl O. A Textbook of Geology, Historical Geology, John Wiley and Sons, 1933, $4.00. Designed as a college textbook, but also a valuable reference for elementary science teachers.

Health

Turner, Claire Eleanor. Principles of Health Education, D. C. Heath Co.,

1932, $2.00. A discussion of health education for teachers in training or in service.

Inventions and Inventors

Hatfield, H. Stafford. The Inventor and His World, E. P. Dutton & Co., 1933, $2.40. The history of invention from a philosophical point of view.

Machines

Collins, A. Frederick. The Amateur Machinist, D. Appleton-Century Co., 1934, $2.00. A guide for the machinist, the common lathe, cutting engine lathe.

Microscope

Yates, Raymon F. Exploring with the Microscope, D. Appleton-Century Co., 1934, $2.00. How to use the microscope as a hobby.

Review Questions

Published by Lester B. Gary. Review Questions in Elementary History.
Published by Lester B. Gary. Review Questions in Elementary Geography.

Science

Newman, H. H. The Nature of the World and of Man, University of Chicago Press, 1933, $1.00. The work of sixteen eminent scientists; subjects ranging from astronomy to psychology.

Thomson, Sir J. Arthur. Science for a New World, Harper and Bros., 1934, $3.75. The scientific outlook on world problems; exponents of scientific thought.

Webb, H. A. An Alphabet of Science, American Education Press. A unique way of presenting scientific subject matter.

Sex Teaching

Strain, Frances Bruce. New Patterns in Sex Teaching, D. Appleton-Century, 1934, $2.00. Designed for fathers, mothers and professional workers dealing with children.

Tests

Schieffelin, Barbara & Schwesinger, Gladys C. Mental Tests and Heredity, Galton Publishing Co., 1932. A brief sketch of the test movement and present day theories of intelligence.

Weather

Shaw, Sir Napier. The Drama of the Weather, Macmillan, 1934, $3.50.

Year Books

Published by the F. A. Owen Publishing Co. The Instructor Year Book, 1933–1934.

Published by the F. A. Owen Publishing Co. The Instructor Year Book, 1934–1935.

Photography

The series of five books on miniature photography in the following list is unique in size as well as content. They are of pocket size and with a flexible binding. Just the size to take with you to read in your leisure time. They are attractively illustrated.

Barleben, Karl A. Jr. *Travel Photography with the Miniature Camera*, Fomo Publishing Co., 1934, 50¢. Stimulating and helpful directions for train, automobile, steamship and yacht, aerial, mountain and seashore photography. Practical suggestions for the miniature enthusiast. The traveler with the larger folding type of camera will do well to have a copy of this book.

Hesse, George W. *Portraiture, with the Miniature Camera*, Fomo Publishing Co., Canton, Ohio, 1934, 50¢. Portraits with a miniature camera! Yes, the results are beyond expectation. The methods by which portraits of professional quality can be produced with a miniature camera are given. Suggestions as to composition, lighting, film, lenses, makeup and development formulas are included.

Wolfman, Augustus. *The Miniature Negative, its Development and Care*, Fomo Publishing Co., 1934, 50¢. Miniature camera workers will find this volume answers many of their questions about miniature negatives. Hints and suggestions on exposure, film, developing, intensifications and reduction, care and handling of negatives.

Buxbaum, Edwin C. *Pictorial Photography with the Miniature Camera*, Fomo Publishing Co., Canton, Ohio, 1934, 50¢. The content is of special interest to the miniature camera worker but it will be helpful to the worker with any size camera. Such topics as technical equipment for the pictorialist and discovering the picture indicate the interesting nature of the content.

Ross, Kip. *Candid Photography*, Fomo Publishing Co., Canton, Ohio, 1934, 50¢. A concise treatment of a special branch of press photography. The technique should be of interest to every owner of a miniature camera.

Bluman, Sigmund. *Photographic Workroom Handbook*, Camera Craft Publishing Co., San Francisco, Calif., 1933, $1.00. A ready reference for the photographic worker. It contains 100 pages of useful information and suggestions. The fact that it is in the fourth edition indicates that it is meeting a real need for the worker.

Strong, William M. *Photography for Fun*, Leisure League, New York, N. Y., 1934, 25¢. How to make beautiful pictures is told in simple language. What equipment to use and how to use it to get the best results is an essential part of the content. One is reminded that photography is a delightful avocation.

Snyder, H. Rossiter. *How to Sell Photographs to Editors*, Rossiter Snyder Publishing Co., New York, 1934, #8 50¢. Persons wishing to make photographs to sell should read such chapters as Choosing your Subject, Farm and Pastoral Scenes, Nature's Beauty Spots, Handling an Assignment, and other helpful topics, discussed in this book.

Snyder, H. Rossiter. *Profitable Photography for the Press*, Rossiter Snyder Publishing Co., New York, N. Y., 1934, #9 50¢. Another helpful book to persons selling or wishing to sell photographs. The content is most practical as is indicated by such chapters as, The Best Approach to a Market, Questions and Answers about Press Journalism.

French, George W. *Photography for the Amateur*, Falk Publishing Co., New York, N. Y., 1933, $3.00. The chapter headings indicate the scope of the subject matter treated in the text—Picture Making, Its advantages as a Hobby, Equipment for the Beginner, Cameras, Lenses, Shutters and their Use, Films and Plates, Taking the Picture, The Darkroom, The Process of Development, Fixing, Washing, Drying, and Filing Negatives, Beginner's Troubles, Series I; Printing; Beginner's Troubles, Series II; Finishing the Picture; Special Treatment of the Negative, Projection Printing; Special phases of Photography;

Miniature Camera Photography; Stereoscopic Photography; Photographic Solutions; How to Make the Camera pay. The illustrations are a delightful and helpful part of the text.

McKay, Herbert C. *The Theory and Practice of Photography,* Universal Photographers, New York, N. Y. A series of eight lessons for the student of the advanced amateur class which according to the author includes the one deeply and seriously interested in photography, professional photographers, and journalistic photographers. Both theory and practice are dealt with in these outlines.

Williams, Leonard A. *Illustrative Photography in Advertising,* Camera Craft Publishing Co., San Francisco, Calif., $3.00. The fundamental principles which govern illustrative work are thoroughly covered in the book. This phase of photography offers a field for especially interesting and creative work. The mechanical means for attaining the illustrative work are covered.

How to Make Good Pictures. Eastman Kodak Company, Rochester, N. Y., 1935, 50¢. The first steps in operating the camera and making pictures are covered in simple language. Delightful illustrations of good pictures.

Cornell Rural School Leaflets

These leaflets are now available to persons not residing in the state of New York at small subscription prices. Cornell University, Ithaca, N. Y.

Natural History

Pickwell, Gayle, Ph.D. Natural History Pictures. $6.00 per set. Publishers Distributing Service. The story of the out-of-doors in pictures. The prints are from actual photographs. A collection of delightful pictures, 8×10 in size. The story of each picture is given in the accompanying text.

PUBLISHERS AND ADDRESSES

Adams: R. G. Adams Co., Fifteenth Avenue and High Street, Columbus, Ohio.

Allyn: Allyn and Bacon, 50 Beacon Street, Boston, Mass.

American: American Book Co., 300 Pike Street, Cincinnati, Ohio.

American: American Education Press, 40 South Third Street, Columbus, Ohio. 580 Fifth Avenue, New York City.

American Radio Relay League Inc., West Hartford, Conn.

Appleton: D. Appleton & Co., 35 West 32nd Street, New York, N. Y.

Blakiston: P. Blakiston's Sons & Co., 1012 Walnut Street, Philadelphia, Pa.

California State Dept. of Education, Sacramento, California.

Camera Craft Publishing Co., San Francisco, California.

Carnegie Institute of Washington News Service Bulletin, Washington, D. C.

Century: The Century Publishing Co., West 112th and Locust Ave., Cleveland, Ohio.

Columbia University: Bureau of Publication, Teachers College, Columbia U., New York.

Cornell Rural School Leaflet, Cornell University, Ithaca, New York.

Curriculum Laboratory, School of Education, Western Reserve University, Cleveland, Ohio.

Dept. of Public Instruction: Commonwealth of Pennsylvania, Harrisburg, Pa.

Dutton: E. P. Dutton & Co., 286 4th Avenue, New York, N. Y.

Eastman Kodak Company, Rochester, New York.

Falk Publishing Co., 10 West 33rd Street, New York, N. Y.
Fomo Publishing Co., Canton, Ohio.

Galton: Galton Publishing Company, West 42nd Street, New York City.
Gary: Lester B. Gary, 31 Berkley Place, Buffalo, New York.
Ginn: Ginn and Co., 199 East Gay Street, Columbus, Ohio.
Globe: Globe Book Company, 175 Fifth Avenue, New York City.

Harcourt: Harcourt, Brace & Co., 383 Madison Avenue, New York, N.Y.
Harr: Wagner Publishing Co., 609 Mission Street, San Francisco, California.
Harter: Harter Publishing Company 2046 East 71st Street, Cleveland, Ohio.
Heath: D. C. Heath & Co., 1815 Prairie Avenue, Chicago, Illinois.
Holt: Henry Holt & Company, 1 Park Avenue, New York, N. Y.
Houghton: Houghton-Mifflin Co., 2 Park Street, Boston, Mass.

Leisure League of America, Inc., New York, N. Y.
Lippincott: J. B. Lippincott Company, 1249 South Wabash Avenue, Chicago, Ill.
Liveright: Liveright Publishing Co., New York, N. Y.
Lothrop, Lee and Shepard, Boston, Mass.
Lyons: Lyons and Carnahan, 221 East 20th Street, Room 508, Chicago, Ill.

Macmillan: The Macmillan Publishing Co., 60 Fifth Avenue, New York City.
McGraw: McGraw-Hill Book Co., 330 West 42nd Street, New York.
Morrow: Wm. Morrow & Co., 386 Fourth Avenue, New York, N. Y.

National Advisory Council on Radio in Education, 60 East 42nd Street, New York.
Nystrom: A. J. Nystrom & Co., 3333 Elston Avenue, Chicago, Illinois.

Orthovis Company, 1328 South Wabash Street, Chicago, Illinois.
Owen: F. A. Owen Publishing Co., Dansville, New York.
Oxford: Oxford University Press, 114 Fifth Avenue, New York, N. Y.

Prentice: Prentice-Hall, 70 Fifth Avenue, New York, N. Y.
Putnam: G. P. Putnam's Sons, 2 West 45th Street, New York, N. Y.
Publishers Distributing Service, 704 South Spring St., Los Angeles, California.

Quarrie: W. F. Quarrie, Chicago, Illinois.

Ramsey: R. R. Ramsey Publishing Co., Bloomington, Indiana.
Rand: Rand McNally & Co., 536 South Clark Street, Chicago, Illinois.
Rockwell: Thomas S. Rockwell, 343 S. Dearborn Street, Chicago, Illinois
Rossiter Snyder Publishing Co., New York, N. Y.

Saalfield Publishing Co., Akron, Ohio or New York, N. Y.
Sanborn: Benj. H. Sanborn & Co., 221 East 20th Street, Chicago, Illinois.
Scott: Scott, Foresman & Co., 623 South Wabash Street, Chicago, Illinois.
Scribner: Charles Scribner's Sons, 597 Fifth Avenue, New York.
Silver: Silver Burdette Co., 221 East 20th Street, Chicago, Illinois.
Smith: Richard B. Smith Inc.
Stanford: Stanford University Press, Stanford University, California.

State University Dept. of Education, Baltimore, Md.
Sun Diet Press, 375 Ellicott Street, Buffalo, N. Y.

Thomas: Charles C, 220 East Monroe Street, Springfield, Illinois.

U. S. Government Printing Office, Washington, D. C.
University of Chicago, 5750 Ellis Avenue, Chicago, Illinois.
Universal Photographers, New York, N. Y:
University: University Series: University Society, 468 Fourth Avenue, N. Y. C.

Webster: Webster Publishing Co., 1808 Washington Avenue, St. Louis, Missouri.
Wiley: John Wiley & Sons, 440 Fourth Ave., New York.
Winston: The John C. Winston Co., 1006 Arch Street, Philadelphia, Pa.
World: World Book Co., Yonkers-on-Hudson, New York.

Zoological: New York Zoological Society, 185th Street and S. Blvd., N. Y. C.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1426. *Vivian Nicholas, Olney (Pa.) H.S., Seymour J. Sherman, New York, G. S. N. Ayyar, Tiruvilwamala, India.*

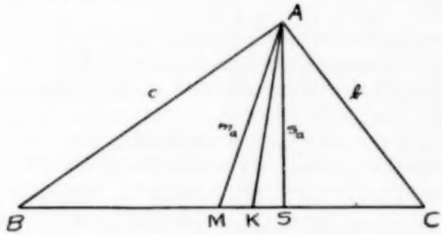
1425. *Charles C. D'Amico, Albion, N. Y., G. S. N. Ayyar.*

1428. *G. S. N. Ayyar.*

1430. *Proposed by Isadore Chertoff, Bayonne, N. J.*

Show that in any triangle, the ratio of a symmedian to its corresponding

median is the same as the ratio of twice the product of the including sides to the sum of their squares.



Solution by W. E. Buker, Leetsdale, Pa.

In triangle ABC, with sides a, b, and c, let S_a and M_a, respectively, be the symmedian and median from A.

Now, $BS:SC=c^2:b^2$. (Altshiller-Court, College Geometry, p. 225).

$\therefore BS:BC=c^2:b^2+c^2$. Hence $BS:MC=c^2:\frac{1}{2}(b^2+c^2)$.

But, since triangles ABS and AMC have a common altitude,

$$\triangle ABS:\triangle AMC=2c^2:(b^2+c^2) \tag{1}$$

Since triangles ABS and MAC have $\angle BAS=\angle MAC$,

$$\triangle ABS:\triangle MAC=AS\cdot c:AM\cdot b \tag{2}$$

From (1) and (2),

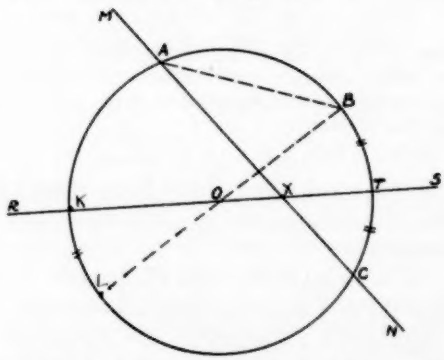
$$2c^2:b^2+c^2=AS\cdot c:AM\cdot b,$$

hence

$$S_a:M_a=2bc:b^2+c^2.$$

Solutions were also offered by Charles W. Trigg, Hugo Brandt, Chicago, and the proposer.

1431. *Proposed by Aaron Buchman, Buffalo, N. Y.*



Given circle O, and points A and B on circle O, and not diametrically opposite. Variable secant MN passes through A and cuts circle O again in C. Variable secant RS passes through O, bisects arc BC and meets MN at X. Find the locus of X.

Solution by Julius Freilich, and Simon L. Berman, Brooklyn.

Given: A, B, and C are 3 points on circle O. RS is a secant passing through the center and the midpoint of $\widehat{BC}$. MN is a variable secant passing through A and C and intersecting RS in X.

Required: The locus of X.

$\angle BOT \overset{\circ}{=} \overparen{BT} \quad \angle BAC = \frac{1}{2}\overparen{BC} \overset{\circ}{=} \overparen{BT}$

$\therefore \angle BOT = \angle BAC$ and $\angle ABO = \angle AXO$

$\therefore$ Point X is on the circle passing through A, B, and O. (If MN does not cross BO, $\angle BOX$ is proved supplementary to $\angle BAC$.)

Conversely, if X is on the circumcircle of $\triangle ABO$, then $\angle ABO = \angle BXO$, or $\overparen{BT} = \overparen{TC} = \overparen{KL}$

$\therefore$ The locus of X is the circumcircle of $\triangle ABO$.

Solutions were also offered by Charles W. Trigg, H. R. Mutch, Glen Rock, Pa., H. Brandt, Chicago, and Seymour J. Sherman, New York City.

1432. *Proposed by Frank M. Walling, Meadville, Pa.*

In traveling 2 miles, the rate of speed of a train in miles per hour is, at every instant, thirty times the distance traveled. What is the time required to travel the 2 miles?

Solution by Julius Freilich and Simon L. Berman, Brooklyn.

If we assume that the train was at rest (had covered no distance) when the law began to operate, then $ds/dt = 30s$ or $1/30 \log s - t = c$. [t represents time in hours, and s the distance covered.]

Now under these conditions when $t = 0$, $s = 0$ and $C = -\infty$. ($\log 0 = -\infty$) and $t = 1/30 \log s + \infty$. Thus it would take an infinite time for the train to travel any distance (no matter how small). In this case, it would never move.

W. E. Buker, Leetsdale, Pa. offered the same solution. Two incorrect solutions were submitted.

1433. *Proposed by Nathan Altshiller Court, University of Oklahoma.*

The sum of the squares of diagonals of the faces of a parallelopiped is equal to twice the sum of the squares of the edges.

Solution by M. W. Keller, Troy, Ohio.

Let the vertices of the parallelopiped be labeled $ABCDEFGH$ such that one of the faces, which are all parallelograms, is $ABCD$, and $AB \parallel CD$. If we let the pair of opposite acute angles of the face $ABCD$ be designated by θ we have by the law of cosines

$$\overline{BD}^2 = \overline{AD}^2 + \overline{AB}^2 - 2\overline{AD} \cdot \overline{AB} \cos,$$

$$\text{and } \overline{AC}^2 = AB^2 + \overline{BC}^2 - 2\overline{AB} \cdot \overline{AD} \cos (180° - \theta).$$

Since the face is a parallelogram the opposite sides are equal and we may write the above equation

$$\overline{AC}^2 = \overline{DC}^2 + \overline{BC}^2 + 2\overline{AB} \cdot \overline{AD} \cos \theta.$$

This equation and the first equation when added give

$$\overline{BD}^2 + \overline{AC}^2 = \overline{AB}^2 + \overline{BC}^2 + \overline{DC}^2 + \overline{AD}^2.$$

Similar results may be obtained for the other faces. It is evident that when these results are added together they will give the desired result.

Solutions were also offered by Charles W. Trigg, Los Angeles, W. E. Buker, H. R. Mutch, Glen Rock, Pa., W. G. Sparks, Port Arthur, Texas, Charles C. D'Amico, Albion, N. Y., Orestes Blake Johnson, Jr., University of Illinois, James A. Lemon, Englewood, Ohio, and the proposer.

1434. *No solution has been offered.*

1435. *Proposed by Cecil B. Reade, Wichita, Kansas.*

Prove that if a fraction a/b, where b is prime, is reduced to a circulating

decimal such that the number of figures in the recurring period is even; then the sum of the first half of the figures in the recurring period added to the last half will consist entirely of nines.

Solution by Charles W. Trigg, Cumnock College, Los Angeles.

If $a>b$ or if $a<b$, the nature of the circulating decimal will be the same, so we will assume that $a<b$. Let the even number of digits in the recurring period be $2k$, and represent the first half of the period by P, the second half by Q. When the division is performed, after P is developed there will be a remainder, m, different from a. After Q is developed there will be a remainder, a. Then $\frac{10^k a}{b}=P+\frac{m}{b}$ and $\frac{10^k m}{b}=Q+\frac{a}{b}$, from which it follows that $(10^k-1)(a+m)=(P+Q)b$. That is, b is a divisor of either (10^k-1) or of $(a+m)$. If b were a divisor of (10^k-1), then $\frac{10^k}{b}=M+\frac{1}{b}$, $\frac{10^k a}{b}=aM+\frac{a}{b}$ and $a=m$. So b is not a divisor of (10^k-1). Now both a and m are less than b, so b can be a divisor of $(a+m)$ only if $a+m=b$, since b is a prime. Therefore $10^k-1=P+Q$, and $P+Q$ consists of K nines.

Solutions were also offered by W. I. Jacobson, New York City and Samuel H. Barkan, New York City.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1433. *Max Fowler, Centralia (Ill.) Township High School.*

PROBLEMS FOR SOLUTION

1448. *Proposed by Samuel H. Barkan, New York City.*

In triangle ABC, if $\cot A+\cot B+\cot C=\sqrt{3}$, prove $A=B=C=60°$.

1449. *Proposed by Maxwell Reade, Brooklyn.*

If $\frac{a-p}{b-p}=\frac{a-q}{q-b}$ prove that $\frac{1}{(a-p)(b-p)}-\frac{1}{(a-q)(q-b)}=\frac{4}{(a-b)^2}$

Note: This is a revision of 1390 which was, as given, incorrect.

1450. *Proposed by Charles W. Trigg, Los Angeles.*

Find a digit, n, which if repeated $(n-3)$ times will be one more than $(n-1)$ to the $(n-2)$nd power. Show it to be unique.

1451. *Proposed by W. E. Buker, Leetsdale, Pa.*

If $ABCD$ is a quadrilateral inscribed in a circle, and O is a point in the plane, show that $\overline{OA}^2\cdot\triangle BCD+\overline{OC}^2\cdot\triangle ABD=\overline{OB}^2\cdot\triangle ACD+\overline{OD}^2\cdot\triangle ABC$.

1452. *Proposed by T. R. Harrison, Dawn, Ohio.*

In a service club of 50 members, the fifth name drawn at random out of a box, containing all the names, receives the prize. What is the probability that the one donating the prize will receive it?

1453. *Proposed by G. S. N. Ayyar, Tiruvilwamala, India.*

Prove that (a) the area of a triangle whose sides are the roots of $x^3 - tx^2 + mx - n = 0$ is $\frac{1}{4}\sqrt{t(4tm - t^3 - 8n)}$.

(b) the altitudes of the triangle are the roots of the equation $8R^3X^3 - 4mR^2X^2 + 2tnRX - n^2 = 0$, where R is the circumradius of the triangle.

SCIENCE QUESTIONS

May, 1936

CONDUCTED BY FRANKLIN T. JONES
10109 Wilbur Avenue, Cleveland, Ohio

Readers are invited to co-operate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio. Thanks!

Your classes and yourself are invited to join the GQRA (Guild Question Raisers and Answerers). More than 130 others have already been admitted to membership by answering a question or proposing one that is published.

Answers are lacking to Questions 731, 733, 734, 737, 738, 739, 740. Submit them to your classes; send in the answers.

BECOME MEMBERS OF THE *GQRA*

GQRA—New Members in 1936—States

114. A. T. Hawkinson, N.J.
115. Arthur L. Hill, Neb.
116. J. A. Nyberg, Ill.
117. J. M. Michener, Kans.
118. Ruth Fremming, N.Y.
119. Bernard Strohm, N.Y.
120. Margaret Hughes, N.Y.
121. Richard Juhasz, N.Y.
122. K. E. Anderson, Minn.
123. B. F. Salisbury, Ohio.
124. V. D. Smiley, Ohio.
125. A. C. Webber, Mass.
126. C. A. Bonsor, Ohio.
127. J. A. Berry, Colo.
128. E. G. Pierce, Ohio.
129. J. M. Synnerdahl, Ill.
130. James Ashley, Idaho.
131. Kenneth P. Kidd, Tenn.
132. E. L. Huber, Ohio.
133. Hugo Brandt, Ill.
134. Sam Otis, Ohio.
135. C. S. Greenwood, Penn.
136. Brother M. Edward, Penn.
137. Olive May Draper, Ind.
138. L. B. Aseltine, Ill.
139. Leslie Buchan, Iowa.
140. Rodney Fickle, Iowa.
141. I. L. Peters, Iowa.
142. James A. Lemon, Ohio.
143. O. B. Sipe, Ohio.
144. W. R. Moore, Ohio
145. E. D. Treece, Ohio.

Above Contributors Come from Fourteen States

Members October to December, 1935

93. M. M. O'Reilly, Dist. Col.
94. Hugh L. Demmer, S. Dak.
95. G. H. Fett, Ill.
96. Delfin Gatchalian, Philippines.
97. Andrea Santiago, Philippines.
98. Feliciano Dizon, Philippines.
99. O. E. Underhill, Conn.
100. Mary Becker, Ohio.
101. Norman Anning, Mich.
102. Jerome L. C. Formo, Minn.
103. Armando Pasco, Rizal, P.I.
104. Borgonio Cruz, P.I.
105. Fernando Mañzalas, P.I.
106. Desgracias Castañada, P.I.
107. Sergio M. Bautista, P.I.

108. Vivencio M. Ceñidoza, P.I.
109. Enfracio C. Quiambao, P.I.
110. Achilles Junitas, P.I.
111. Biennenido F. Miranda, P.I.
112. R. H. Gocker, Ill.
113. L. J. Rentsch, Ohio.

Additional Contributors come from Five States and One Foreign Country

A SCIENCE QUESTION

754. *Proposed by C. S. Greenwood (Elected to GQRA No. 135), Sheffield, Pa.*

A cake of ice at 0 degrees C. is floating in a tub of water, the tub, water, and air of the room also being at 0 degrees C., and the temperature of the air is controlled by outside means.

1. Aside from the difficulty of obtaining the above conditions, what will happen?
2. What factor is missing from the statement of the question, and what difference will it make?

FROZEN WATER PIPES

755. *Proposed by Olive May Draper (Elected to GQRA, No. 137), Taylor University, Upland, Ind.*

I have been told several times this winter that the warm weather drives the frost down into the ground, and that is why the water lines were frozen. Is that the reason?

The specific example was this: there was a long spell of very cold weather followed by one mild day, when the surface of the ground became muddy in spots, and some snow melted off. It turned cold towards morning, and that morning three water lines in this immediate neighborhood were frozen.

I would appreciate comments from your members.

QUESTIONS FROM STUDENTS

756. *Submitted by Leslie Buchan (Elected to GQRA, No. 139), Science Class, Clarion, Iowa.*

When water, sand and cement are mixed together they form a paste. This paste will harden even though covered with water and when no evaporation is allowed to take place. What is the scientific principle involved?

757. *Submitted by Rodney Fickle (Elected to GQRA, No. 140), Junior High School, Clarion, Iowa.*

A pan full of water and a pan full of ice are placed in a refrigerator held at exactly 32 degrees F. Will the ice melt? Will the water freeze?

Transmitted by I. L. Peters, Instructor, Junior High School, Clarion, Iowa. (Elected to GQRA, No. 141.)

WHAT ARE YOUR VIEWS?

Submitted by Principal James A. Lemon, Randolph High School, Englewood, Ohio. (Elected to GQRA, No. 142.)

Mr. O. B. Sipe (*Elected to GQRA, No. 143*), Chemistry and Physics

Teacher, Randolph H. S., and I have had a few discussions concerning the following questions. We have answers for these but would like to hear other views and comments.

758. Our text in physics gives the following statement: "The over-crowded electrons on the zinc plate (of a simple electric cell) try to push each other off the plate, and this push, together with the attraction of the + plate, is the electromotive force of the cell." We infer that electrons go from − to + through a wire connecting the plates. Diagrams in this book show that electric current from batteries and DC generators flow from + to −. IS THE CURRENT FLOWING IN THE DIRECTION OPPOSITE THAT OF THE ELECTRONS?

759. Why does a gyroscope resist a change in direction of its axis, if there is no substance in space called ether?

A CHEMISTRY TEST

760. *Submitted by W. R. Moore, (Elected to GQRA, No. 144), Brush High School, South Euclid, Ohio.*

CHEMISTRY 11A

CHEMICAL APPLICATIONS, June, 1935

Directions: Choose from Column I, the best answer for the use indicated in Column II. Place the number of the Answer chosen in the space provided at the right of the question.

Column I (*Answers*)	Column II (*Uses*)	(*Your Answer*)
1. Acetic acid	1. Frosting light bulbs	1. 18
2. Acetylene	2. To make anti-knock gasoline	2. 15
3. Alum	3. Goiter preventive	3. 20
4. Aqua regia	4. Incendiary bullets	4.
5. Bauxite	5. Fertilizer	5. 7
6. Calcium chloride	6. Ingredient for making "carborundum"	6. 28
7. Calcium phosphate	7. To preserve food	7. 29
8. Carburetor	8. To make *blue* gas	8. 13
9. Carbon monoxide	9. Constituent of natural gas	9. 23
10. Carbon tetrachloride	10. An anaesthetic	10. 16
11. Charcoal	11. Non-explosive cleaner	11. 10
12. Chalk precipitated	12. To vaporize gasoline	12. 8
13. Cobalt	13. Explosive in dynamite	13. 25
14. Copper sulphate	14. Mothicide	14. 24
15. Ethylene bromide	15. Found in baking powder	15. 30
16. Ethyloxide	16. Polishing agent in tooth paste	16. 12
17. Gold	17. To lay dust on roads	17. 6
18. Hydrofluoric acid	18. A laxative	18. 22
19. Hydrochloric acid	19. Used in welding	19. 33
20. Iodine	20. Used in water purification	20. 3
21. Iridium	21. Used to soften hard water	21. 34
22. Magnesium sulfate	22. Solvent for gold	22. 4
23. Methane	23. To weight silk	23. 32
24. Napthalene	24. To tip fountain pens	24. 21
25. Nitroglycerin	25. In spray for fruit trees	25. 14
26. Phosphorus		

27. Radium
28. Silicon dioxide
29. Sodium benzoate
30. Sodium bicarbonate
31. Sodium phosphate
32. Stannic chloride
33. Thermite
34. Zeolite
35. Zinc

26. In treatment of cancer..........26. 27
27. To remove silver from lead.......27.____
28. To coagulate rubber............28.____
29. Source of aluminum............29. 5
30. To make glass *red*..............30.____

(*It is interesting to note that Mr. Moore has more answers than questions, Ed.*)

A BIOLOGY TEST

10B Biology **Semester Test**

761. *Submitted by E. D. Treece (Elected to GQRA, No. 145),* ***Brush High School, South Euclid, Ohio.***

Directions—Place a plus (+) on the line before each statement you consider true and a zero (0) before each statement you consider false.

____ 1. New varieties of plants are secured by self-pollination.
____ 2. Rocks are organic.
____ 3. Oxygen is a compound.
____ 4. Iron is an element.
____ 5. Air is a mixture.
____ 6. Rusting of iron is a chemical change.
____ 7. Burning of hydrogen is a physical change.
____ 8. Carbon is a solid.
____ 9. Proteins are used principally in building and repairing cells.
____10. Kinetic energy is active energy.
____11. Energy cannot be created.
____12. Matter can be destroyed.
____13. All food comes originally from plants.
____14. Osmosis is the passage of solutions through a membrane.
____15. The shedding of leaves reduces transpiration.
____16. The veins of a leaf are in the lower epidermis.
____17. The cutin lies between the upper and lower epidermis.
____18. Chlorophyll can develop in darkness.
____19. Grasshoppers have jointed appendages.
____20. Insects have four pairs of legs.
____21. The body of insects is divided into head, thorax, and abdomen.
____22. Spiracles are part of the respiratory system of insects.
____23. The trachea are part of the digestive system of insects.
____24. The tympanic membranes are used for hearing.
____25. The spider is an insect.
____26. The skeleton of the grasshopper is an exoskeleton.
____27. The special smelling organs of the grasshopper are located on the thorax.
____28. The mouth parts of the grasshopper are adapted to sucking.
____29. The grasshopper has incomplete metamorphosis.
____30. The culex mosquito carries malaria.
____31. An animal that lives on a living animal is called a parasite.
____32. Birds are natural enemies of insects.
____33. The skeleton of the crayfish is an endoskeleton.
____34. The green gland of the crayfish is an organ of excretion.
____35. Ticks belong to the arachnids.

_____36. The spider has eight walking appendages.
_____37. A fish chews its food.
_____38. The heart of the fish consists of two chambers.
_____39. The heart of the frog has three chambers.
_____40. The horned toad is a lizard.
_____41. Toads are beneficial to man.
_____42. Cowbirds lay their eggs in the nests of other birds.
_____43. The whale is a fish.
_____44. Bats are mammals with feathers on their wings.
_____45. The starfish swallows its food.
_____46. Mammals are invertebrates.
_____47. A ruminant is an animal that chews its cud.
_____48. The tapeworm is a round worm.
_____49. The teeth of rodents are developed for gnawing.
_____50. Mammals have four divisions in their hearts.

HALOS AND MOON DOGS

744. *Proposed by John A. Berry, (GQRA, No. 127), Wiley, Colo.*

Answers by Charles C. D'Amico (GQRA, No. 49), Albion, N. Y.

(*a*) What Mr. John Berry observed were halos or coronas around the moon. The halos generally have a radius of 22°, but may extend to 45° or 90°. Coronas have a much smaller circle, generally from 1° to 10°. These are usually white, but may be colored (rainbows).

The upper atmospheric conditions must be just right for these phenomena. Cirrus clouds which are composed of myriads of ice particles (specules) floating high in the air and moonlight (reflected sunlight) are necessary conditions. Dust and water particles also play a part (the larger the water particles, the smaller the circle). The rays of light striking the ice or water particles are reflected only, or diffracted and refracted. If the degree of refraction is high, beautiful colored rings (rainbows) are formed. The halos sometimes have a number of rings. At times these rings are separate; at times the rings intersect. At the points of intersection there usually appear bright circular patches of light, called moon dogs or mock moons. This is an impressive phenomenon. Sun dogs may occur during the day.

(*b*) It is colder just before sunrise than an hour or two before or after because just before sunrise radiation of heat from the earth is at its maximum (for the night). Just as it takes time for the atmosphere to warm up during the day, and therefore, the warmest period of the day is usually after noon and not at noon when the sun's rays are more direct, so the coldest period is not at midnight but after midnight when the earth is turned away from the sun. It takes time for the atmosphere to cool. Consequently the cooling continues till sunrise. In as much as radiation is continuing all the time, with no absorption of solar energy, the coldest period would come just before sunrise. Of course atmospheric conditions may be such that this condition would not prevail. Our weather, of which temperature is an important element, is very fickle. In these latitudes, highs and lows are controls.

A NEW ANSWER

683. *Submitted by L. B. Aseltine (Elected to GQRA, No. 138), Joliet, Ill.*

Concerning the question, "What is twice as cold as zero?"

It cannot be answered according to the ordinary meaning, because no one knows what that meaning is. At what temperature does it begin to get cold? If we knew that, we could answer, but there is no such generally accepted point.

We must turn then to the technical answer. I submit that there is only one possible, and I have not seen it given. Since 0° is 273 degrees of heat, and therefore a negative 273 degrees of cold, twice as cold would be 546 above absolute zero or 273 degrees Centigrade. Cold? No, but neither is zero! In other words, it is the same as asking the question, "A is worth $100. B is twice as far in debt as A. How much is B worth?" Since A's worth is $100, his *debt* is—$100, and a person twice as far in debt would have *a debt* of—$200, or would, in other words, be worth $200.

Of course, the whole thing is silly, (but we all like silly things). Twice as cold has no meaning. A dish has in it two inches of water. Another is twice as empty. What does that mean? Nothing. Twice as empty does not mean half as full. Twice as cold does not mean half as hot. Twice as short does not mean half as tall. They *have* no meaning. They are simply inaccuracies of speech.

HEAT AND COLD

741. *Proposed by Alfred C. Webber (GQRA, No. 125), Brookline, Mass.* and **683.** *Proposed by Kasimeria Koerzat (GQRA, No. 51), Buffalo, N. Y.*

Answers by Charles C. D'Amico, (GQRA, No. 49), Albion, N. Y.

(1) What is heat?

Heat is the kinetic energy of the motion of molecules.

The heat possessed by a body is equal to the total kinetic energy of its molecules.

Radiant energy is a transverse wave motion traveling with the velocity of light. Radiant energy becomes heat only when it falls on a body capable of absorbing it. Radiant energy may be converted into other forms of energy such as light, electricity, etc.

Temperature is the condition which determines in what direction heat is transferred. Heat is always transferred from a body of high temperature to a body of low temperature. Temperature is a relative term and is a means of comparing the relative speeds of the molecules of bodies. For instance, if we take the temperatures of bodies A and B and find that the temperature of body A is higher than that of B, we know then that the velocity, and therefore, the kinetic energy, of the molecules of body A is greater than that of the molecules of body B. We also know that if body A were connected to body B by a conductor of heat, that heat would be transferred from body A to body B until both had the same temperature. Temperature and heat must not be confused. For instance, a cup of hot water and a pail of hot water may both have the same temperature, but they will not have the same amount of heat. The body with the larger mass will have more heat because it will have more molecules and therefore, more kinetic energy.

Degrees of heat and degrees of temperature are the same. Temperature is used to indicate degree of heat.

There is no such thing as cold. Cold denotes the absence of heat.

Twice as cold means *more appropriately* half as hot.

As regards problem 683, diagrams can be used to answer the questions.

If heat is the kinetic energy of molecular motion, the heat that a body possesses depends on the motion of its molecules. If the molecules of a body are at rest, the body can therefore have no heat. The point (temperature) at which the motion of the molecules of a body ceases, is called Absolute Zero (temperature of no heat).

The matter of how much colder twice as cold as zero is, or three times as cold as zero, can best be explained by simple diagrams.

Let lines represent three temperature scales

	Absolute	Centigrade	Fahrenheit
Boiling point of water	(373° A.)	(100° C.)	(212° F.)
Freezing point of water	(273° A.)	(0° C.)	(32° F.)
Half as hot as, or twice as cold as zero	(136.5° A.)	(−136.5° C.)	(−229.7° F.)
One-third as hot as, or three times as cold as zero	(91° A.)	(−182° C.)	(−153.1° F.)
Absolute zero	(0° A.)	(−273° C.)	(−459.4° F.)

Therefore, −136.5° C. is one-half as hot as, or twice as cold as 0° C., and −91°C. is one-third as hot as or three times as cold as 0° C.

Therefore, −229.7° F. is one-half as hot as, or twice as cold as 0° F. and −153.1° F. is one-third as hot as, or three times as cold as 0° F.

BOOKS RECEIVED

Unified Physics, by Gustav L. Fletcher, Chairman, Department of Physical Science, James Monroe High School, New York City; Irving Mosbacher, Late Chairman, Department of Physical Science, Morris High School; and Sidney Lehman, Department of Physical Science, James Monroe High School, New York City. Cloth. Pages xii+662. 13.5×20.5 cm. 1936. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.80.

Procedure in Taxonomy, by Edward T. Schenk and John H. McMasters. Cloth. Pages vii+72. 15×23 cm. 1936. Stanford University Press, Stanford, California. Price $2.00.

Through the Telescope, by Edward Arthur Fath, Professor of Astronomy in Carleton College. Cloth. Pages vii+220. 15×23.5 cm. 1936. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.75.

General College Chemistry for the Laboratory, by Rufus D. Reed, Associate Professor of Chemistry, New Jersey State Teachers College at Montclair and Robert W. McLachlan, Assistant Professor in Science, New Jersey State Teachers College at Montclair, N. J. Paper. Pages x+87. 20×27.5 cm. 1935.

295 American Birds, by Thomas S. Roberts. Spiral binding, hard cover. 92 color plates. 20.5×27.5 cm. 1934. The University of Minnesota Press, Minneapolis, Minnesota. Price $2.00.

Adult Education in Hamilton County, Ohio, 1934–1935, by Miriam Walker, Executive Secretary. Paper. 19 pages. 14×21 cm. Adult Education Council of Metropolitan Cincinnati, 629 Vine Street, Cincinnati, Ohio. Price 25 cents.

Suggested Theory of Trade Winds and Gulf Stream, by A. A. Alles. Paper. 18 pages. 12×17.5 cm. 1935. A. A. Alles, 1504 Federal Street, Pittsburgh, Pa.

Arithmetic for Business Training, by Alexander Fichandler, Principal, Junior High Schools, Brooklyn, New York; Louis Slatkin, Teacher in Junior High Schools, Brooklyn, New York; and Murray Melzak, Teacher in Junior High Schools, Brooklyn, New York. Cloth. Pages v+163. 12.5 ×19 cm. 1936. Globe Book Company, 175 Fifth Avenue, New York, N. Y. Price $1.00.

New Practical Chemistry, by Newton Henry Black, Assistant Professor of Physics, Harvard University and James Bryant Conant, President of Harvard University. Cloth. Pages x+621. 13×20 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

Science for Today, by Otis W. Caldwell, Professor Emeritus, Teachers College, Columbia University and Francis D. Curtis, Teacher of General Science and Head of the Department of Science, University of Michigan High School, and Professor of the Teaching of Science, University of Michigan. Cloth. Pages xvi+733+xxii. 13×20 cm. 1936. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.68.

BOOK REVIEWS

Senior Chemistry for Canadian High Schools and Colleges, by George A. Cornish, B. A., Professor of Science, College of Education, University of Toronto. First Edition. Pages viii+689. 2.8×15×21cm. Tables 62 plus 10. Figures 166. Maps 2. (Western and Eastern sources of chemical products.) Cloth. 1934. The Copp Clark Co, Ltd. Toronto.

Comes now something new under the sun. First, the author is a Professor of Science and he lives up to his title and teaches sciences in their inter-relations in his book. Then, too, he has cast off all controls and inhibitions and felt free to follow a new order of treatment of his material. As this text is intended for students who have had the usual year of elementary work the author is free to assume that some of the ideas and language of chemistry are already available for use so he goes right to work on the fundamentals of the theory of solutions, the structure of matter, chemical equilibrium, electro-chemistry the periodic law, subatomic structure, atomic number, isotopes, radioactivity etc and then follows a systematic study of the families of elements in the order of the periodic table. We have then, first a textbook of general and physical chemistry followed by a text on inorganic chemistry. (There is a very brief chapter on qualitative analysis at the end of the book which the reviewer hopes nobody ever reaches.)

The subject matter of this text is excellently taught with the factual background given first and the theoretical explanations based on the facts and always differentiated. The psychological approach is generally good.

While the book is frankly designed for use in Canada the reviewer can see no good reason why we, in the United States, should not have the benefit of such a good piece of work for use in situations such as it was designed to fit.

FRANK B. WADE

New Practical Chemistry, Fundamental Principles Applied to Modern Life, by Newton Henry Black, Assistant Professor of Physics, Harvard University. (Formerly Science Master, Roxbury Latin School) and James Bryant Conant, President of Harvard University, (Formerly

Professor of Chemistry). First Edition. Pages x+619. 3×14×20 cm. Figures 329 plus charts and tables. Cloth. 1936. Macmillan Company, 60 Fifth Avenue, New York, N. Y. List price $1.80.

The mantle of Charles W. Eliot has fallen upon his successor, for that great educator was first a successful chemistry teacher and author of a series of splendid texts and then President of Harvard and that has been the route of President Conant. It would seem that chemists have been particularly sought for executive positions even since the day of Remsen. To complement Dr. Conant's work his co-author has a notable history of secondary school teaching and administration followed by a chair in Harvard and accompanied by numerous successful textbook ventures.

As a result of this "team-work" we have in this new book a text which is sure to be a practically usable one. A brief study of it shows that the authors are of the opinion of Polonius that one should "be not the first by whom the new is tried nor yet the last to lay the old aside." The psychological sequence is excellent. We note that such a topic as neutralization, for example is first treated very simply, then, when ionization has been introduced, the fuller treatment is offered, thus using what may be called a "spiral" method of teaching. The newer concepts of atomic complexity are presented at a reasonably early stage of the work and made use of thereafter. Heavy water, anti-knock gasoline, tempered glass and other modern things show that the book is not lacking in up-to-date characteristics. It is heartening to find in the account of the industrial preparation of metallic sodium, the very method which we found in use at Niagara Falls, Ont. a few weeks ago rather than one which an old foreman at the plant said he had ceased to use twenty years ago.

Enough has been said about this new text so that all chemistry teachers who may be considering a change of text will want to make a study of it.

FRANK B. WADE

The Invertebrata, by L. A. Borradaile, Fellow of Selwyn College, Cambridge; F. A. Potts, Fellow of Trinity Hall, Cambridge; with Chapters by L. E. S. Eastham, Professor of Zoology in the University of Sheffield, and J. T. Saunders, Fellow of Christ's College, Cambridge. Second Edition. Cloth. Pages xv+725. 14×22 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

This book is the product of Darwin's Alma Mater (Cambridge University, England). One may anticipate that it will be welcomed by students of Zoology in this country quite as much as by those in its native habitat. It presents a fresh and stimulating point of view on many topics, among which might be mentioned Classification and Phylogeny. Designed as a textbook for students who have already had a year of college zoology, it omits detailed descriptions of the classic types found in most general texts; the space thus conserved is filled with interesting material not found in the usual run of texts. Those who are not primarily interested in the invertebrates will find it a valuable reference book. In clearness of expression and general interest the authors have set a high standard.

The invertebrate phyla are taken up in phylogenetic order, the most important ones quite extensively, e.g., Protozoa, with 110 pages; Arthropoda, with 238 pages. The final chapter treats the Hemichorda and Tunicata in some detail, but does not consider the Cephalochorda.

In the matter of classification, it is apparent that we have come a long way since the days of Linnaeus, with the animal kingdom divided into only six major groups, for, in this book there are no less than nineteen phyla recognized, exclusive of the Chordata. To the reviewer it seems that

the authors might have made it an even score of phyla by giving the Ctenophora phylum ranking, instead of relegating them to the position of Subphylum under the Coelenterata.

The book is well illustrated with many diagrams and drawings, most of which are redrawn and many of which are original. In the matter of labeling figures, the book follows the older method of using abbreviations, with explanations printed below. This method, from the standpoint of rapidity of reference and kindness to the eyesight, is greatly inferior to the method recently gaining favor in this country, viz., the printing of labels directly opposite the structure.

The present edition has been enlarged by 80 pages over the first (1932) edition. The index of 39 pages is unusually complete.

The publishers are to be congratulated on the excellent typography and the substantial binding.

E. C. Colin

Chemistry Experiments and Exercises, by A. J. Burdick and J. J. Dudleston, both of Utica Free Academy, Utica, New York. Paper. Pages viii+200. 21×26.5 cm. 1935. The L. W. Singer Company, 249–259 West Erie Blvd., Syracuse, N. Y. Price 69¢ list.

This Manual of seventy chemistry experiments brings laboratory work into close relation with the subject as it is considered in the class room. Each of the twelve parts begins with a list of textbook references; thus the manual is easily adapted to any of our leading texts. Most of the experiments are introduced by excellent historical notes and each experiment closes with some related questions. Simple drawings are provided where necessary; they require labelling and thus save time but demand interpretation. Each experiment appears complete on a single sheet which is perforated so it may be torn out and handed in for grading. For each part there is also a sheet of supplementary material containing (1) a scientific vocabulary; (2) topics for class discussion; (3) projects for laboratory or home work; and (4) a review exercise or test.

The work is well organized, clear, and definite. The student records his findings by filling in blanks; some teachers consider it essential that such laboratory records be made as complete independent statements. The manual has an attractive cover and is printed in clear, readable type on a good grade of paper, corners rounded.

The fact that so much good material is concentrated within a thickness of less than a centimeter is a distinct merit. Those who examine this manual will like it; many will use it.

W. F. Roecker

Chemistry Workbook and Laboratory Manual to Accompany Units in Chemistry, by Russell S. Howard, Head of the Science Department, Lyons Township High School and Junior College, La Grange, Illinois. Illustrations by Mrs. Russell S. Howard. Paper. Pages xi+305. 21×28 cm. Henry Holt and Company, New York. 1936. Price 96¢.

This manual is a comprehensive and thorough piece of work. Sixty eight experiments are included in eight units. The tying up of experiments into units is commendable especially when the units consist of the fundamental concepts of chemistry, as these do. The questions included in each experiment are quite searching and exhaustive. The illustrations are clearly drawn and will lead to no misconceptions.

No effort has been made to adjust the length of the experiments to

any particular length of laboratory period. The aim is to include all of the material bearing upon the chosen topics within one experiment. The author is correct in not making each experiment a small chopped up unit in itself. As the experiments dealing with the subject matter of each unit have been grouped together and in the same order in which the underlying principles are discussed in the accompanying text, Units of Chemistry, the manual is primarily useful for those schools using this text.

A discussion has been placed at the beginning of each experiment for the purpose of supplying some background in the student's mind. More material has been included in this book than can be properly covered in the time allowed for laboratory study, but its scope offers opportunity for selection. The space for recording observations has been placed adjacent to the laboratory instructions. This is a time saver for both student and teacher. More well selected problems would prove of value.

Teachers of chemistry will find it worth their while to examine this manual. The intelligent student will enjoy the searching type of questions.

W. McCrory

First and Second Year Algebra Combined, by Herbert E. Hawkes, Ph. D. Professor of Mathematics in Columbia University; William A. Luby, Head of the Department of Mathematics in the University of Kansas City, and Frank C. Touton, Ph. D., Professor of Education in the University of Southern California. Pages vi+735. Ginn & Co., Chicago, 1935.

This is a book that combines a first and second year Algebra Course, as its title implies, in a form that would be convenient for use in courses that are more than a year in length.

The first twenty chapters combine the first year work in Algebra, beginning with an interesting unit on the introduction to Algebra, and ending with a unit on quadratic equations. The second part of the book deals with more advanced work, beginning with a review of the fundamentals and extending through a unit on Progressions.

The book is so organized that the first chapters of Part II may be omitted with those classes that are not in need of this review work, while the last chapter forms additional material for an enriched course for superior students, or classes.

New features, such as unit summaries and unit review questions, have been effectively introduced.

The psychological development of the subject matter, plus the well-integrated organization of the material, has been carried out, in compliance with sound and up-to-date education principles.

Outstanding features of this book are:

1. An unusually well-integrated arrangement of the study of the equation, from the most simple to those of succeeding difficulties.
2. An equally fine, correlated amount of graph material.
3. An enriched group of verbal problems that are thought-provoking, and pertinent to the present time.
4. A large amount of drill material, both oral and written, adaptable to individual differences.
5. A purposeful study of formulae, and their application and correlation to verbal problems, and to science.
6. A number of interesting and illuminating historical notes that will add to the cultural enrichment of the study of algebra.
7. A well-defined chapter of trigonometric material.

For the teacher who desires a book to meet the individual needs of his

students and classes, he will find that the flexibility of this book, and the wealth of its material, will give him ample opportunity to carry out this purpose.

CONSTANCE VAN NESS

Study Arithmetics—Series of Two Books for Grades 4–5, by F. B. Knight, G. M. Ruch, J. W. Studebaker and W. C. Findley.

This series of books meets the demands of educators for increased motivation, opportunity for social enrichment, appreciation of mathematics, and an upward shifting in the grade placement of long division and fractions.

The books are extensively and harmoniously illustrated. The lessons in story problems are practical problems so illustrated as to give the pupil a clear vision of the problem stated. The type of print and color of the paper used are suitable for the eyes of the younger pupils. The vocabulary is simple and sentence structure is not complicated. Quick drills, individual pupil checks, and sufficient reviews are provided. A distinction between "long" and "short" division is not made which makes for a more economical and less confusing process.

In the fourth grade unit the first chapter prepares the pupil for new work by reviews and drill; chapters 2–7 deal with multiplication. Expanded treatment of each new step and objective measurement of pupil progress is used; chapter 7 deals with the introduction of fractions and their uses in practical problems; chapter 8 takes up division by two figure numbers. The last chapter is spent getting the pupils ready for the next year's work by means of problems, reviews, and drills.

In the fifth grade unit the first chapter prepares the pupil for his new work. Chapters 2 and 3 develop division first with easy numbers then with more difficult numbers; chapters 4–7 develop fractions and lead step by step to mastery of all the functions of fractions; chapter 7 is spent in giving knowledge of lines and areas; chapter 8 gives information about the use of measures; chapter 9 prepares the pupil for the coming year's work.

This series is provided with adequate prefaces, tables of contents, supplementary material, and indices.

MARIE E. SHIELDS

First Course in Algebra, by Harry C. Barber, Instructor in Mathematics in the English High School, Boston and Elsie Parker Johnson, Instructor in Mathematics, Oak Park and River Forest Township High School, Oak Park, Illinois. Pages xvii+425. 1935. Houghton Mifflin Company, Boston, Chicago, San Francisco.

Barber and Johnson present a modern book which retains the worthwhile material of the past and adds the problems of life situations of today. Emphasis is placed upon algebra as a symbolism for thinking and as a purposeful subject.

The outstanding features which should lead to the use of Barber and Johnson's book by progressive Senior High Schools are:

1. It facilitates an effective balance of skill and understanding.
2. It acquaints the pupil with thought-provoking problems.
3. It is written in clear style.
4. It is printed from large type.
5. The subject-matter is arranged in a psychological manner.
6. The problems create interest.

7. Many oral and written exercises are given.
8. It leads the child to make his own discoveries, to make comparisons and appraisals.
9. It has purposeful material, which provides for individual differences.
10. It has objective tests.
11. Number relationship is shown by graphs, tables, and formulas.
12. The verbal problems stress thinking, and are correlated with arithmetic, geometry and trigonometry.
14. The equation is the nucleus around which the work in each unit is built.
15. It provides for individual differences by offering minimum, standard, and maximum courses.

If you are in need of a book, where interest is focused upon the development of the mathematical ideas themselves and upon the progress therein, you will choose Barber and Johnson's "First Course in Algebra." It will meet this need.

BESSIE B. KINERT

Mathematics in Life, Unit A—*Measurement in Modern Life* and *in the Long Ago*, by Raleigh Schorling, Head of Department of Mathematics, the University High School and Professor of Education, University of Michigan and John R. Clark, The Lincoln School of Teachers College, Columbia University. Kraft. iv+44 pages. Illustrated. 1935. Yonkers-on-Hudson, New York. World Book Company.

Th is pamphlet, the first unit in a series of mathematic units, is designed to help the slow-learning students.

It is known, and admitted, by many teachers that the non-mathematically minded students are "lost" in a rigorous formal course and that something must be done for them. Here is a course, that not only meets this problem, but contributes definite, worth while, and lasting benefits.

Some of the content of this unit is as follows:

1. The meaning of Measurement.
2. Measuring in the Long Ago.
3. The struggle for more exact standards.
4. Man shoves the error to the next Decimal Place.
5. How Man learned to use numbers in the long ago.

The authors have employed various devices and methods to make this unit of interest and importance to the individual student. One device is the use of "story form." The historical background relating to the long and laborious struggle to develop mathematics to its present stage is interestingly unfolded. In this manner the fundamental principles and concepts are closely integrated with the concrete and the practical side.

The exercises are carefully graded, step-by-step: confidence is built up from the beginning. Frequent and comprehensive tests contribute favorably toward complete learning of the unit.

The booklet contains, a final test on the unit, objectives (for the teacher), many interesting exercises, an abundance of reading material and an index. Teachers of mathematics, will find this pamphlet, "just the thing" in dealing with the "slow, dull and seemingly helpless student."

However, it should not be confined to this one group, as it should prove equally valuable with brighter students.

HYMEN D. SILVERMAN

Integrated Mathematics with Special Applications to Analysis, by John A. Swenson, Ph.D., Head of Department of Mathematics, Wadleigh High

School, New York City and Associate in Mathematics, Teachers College, Columbia University. Book V, Cloth. 473 pages. 1935. Edwards Brothers, Inc., Ann Arbor, Michigan.

This book the fifth one in a series of books dealing with Integrated Mathematics employs the calculus as the medium of correlating the various parts of algebra, geometry, and trigonometry. Such fundamental concepts as rate of change, and finite differences are included.

The book is divided into thirteen chapters and the topics dealt with are as follows:

1. The function concept.
2. The linear function.
3. The number systems of algebra.
4. The polynomial function.
5. The conic sections.
6. Limits. Differentiation.
7. Integration.
8. Differentials.
9. Logarithms.
10. Permutations and combinations.
11. Probability and statistics.
12. Life insurance.
13. Determinants.

Throughout the book the author has analyzed, arranged, outlined, and summarized the important steps in the solutions of the various units. He has included a great many exercises, illustrative examples, and supplementary materials.

The book is well organized, clear and concise. It contains various tables, such as roots and powers, four-place logarithms of numbers, four place trigonometric functions, and an index.

Instructors in mathematics will find this book stimulating and useful in their courses.

HYMEN D. SILVERMAN

THE SOLAR ECLIPSE OF JUNE 19

A group of American scientists are going to Siberia next June in the hope of solving one of the major mysteries of science. They hope to establish the nature of the mysterious "coronium" which exists in the sun.

On June 19 an eclipse of the sun will be observable in a narrow track across Siberia. During the eclipse, the corona of the sun, a great pearly halo, will be visible. In order to study it a large spectrograph, with a special telescopic extension, has been constructed by Gustave Fassin and Harold W. Straat in the Scientific Bureau of the Bausch & Lomb Optical Co. With this gigantic 700 pound spectrographic camera, Dr. Donald H. Menzel, of the Harvard College Observatory, who heads the Siberian expedition, hopes to determine whether "coronium" is really a chemical element unknown on earth or whether it is a chemical element already known which exists under extraordinary conditions in the sun.

A record of the spectrum of the corona will be taken throughout the progress of the eclipse, the spectrograph being suspended in a special cradle for this purpose.

Dr. Menzel, and his assistants, Dr. Joseph C. Boyce, of the Massachusetts Institute of Technology and Henry Hemmendinger, of Harvard, hope to discover the important secret which the corona is believed to contain.